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**BULLETIN No. 476**

**Contribution from Office of Markets and Rural Organization,
Charles J. Brand, Chief, and North Carolina Agricultural Experiment Station and Extension Service,
B. W. Kilgore, Director.**

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# A STUDY OF COTTON MARKET CONDITIONS IN NORTH CAROLINA WITH A VIEW TO THEIR IMPROVEMENT.

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## INTRODUCTION.

The investigations described in this bulletin were made for the purpose of ascertaining the value to the cotton producer of knowing the class of his cotton before sale and for the purpose of determining whether this information could be furnished to producers by disinterested parties with practical results. It is realized that in the marketing of cotton by producers a knowledge of class before sale is only one of a number of related problems, some of which were studied and are discussed in this paper.

A detailed investigation of local conditions affecting the marketing of cotton was made in North Carolina during two seasons. This investigation was confined to the eastern part of the State during the season of 1914–15, and embraced all cotton-producing sections during the season of 1915–16.

## METHOD OF PROCEDURE.

Arrangements were made with practically every ginner in Edgecombe County to sample each bale of cotton ginned during the 1914–15 season and mail the samples to the classing room at Tarboro.[1] Samples from about 10,700 bales ginned in the county were received. These samples were graded and stapled, and this information was mailed to the producer on a card, numbered to correspond with the bale from which the sample was taken, with a letter explaining in detail the purpose of the investigation. The farmers were circularized frequently, to help them to understand the approximate differences in prices that should be made between grades.

The investigation was conducted in a similar manner during the 1915–16 season on an enlarged scale, classers being appointed for the following counties: Edgecombe (the cotton ginned in Nash County was classed by the Edgecombe classer also), Mecklenburg, Wilson, and Wayne.[2] Samples from about 30,000 bales ginned in these counties were received and classed.

Samplers were appointed during the 1914–15 season at Fayetteville, Goldsboro, and Scotland Neck, all of which are located on the Coastal Plain section, to collect samples of bales of cotton, sold at these towns, the class of which was unknown to the producer before sale. Inclosed with each sample sent to the classing room at Tarboro was a record slip giving the price at which the bale sold and the date of sale. About 3,500 samples of bales of cotton sold at these towns were received. During the season of 1915–16 the collection of samples in this manner was extended to include Ahoskie, Clinton, Gastonia, Jacksonville, Kings Mountain, Kinston, Laurinburg, Louisburg, New Berne, Raleigh, Red Springs, Salisbury, Selma, Statesville, Wadesboro, and Washington. Samples drawn from about 14,000 bales sold at these towns were received. An attempt is made in the map (see fig. 1) to illustrate the extent to which these towns represent the cotton-producing area of the State.

## CHARACTER OF THE COTTON PRODUCED IN NORTH CAROLINA.

### AVERAGE GRADE AND LENGTH OF STAPLE.

During the season of 1914–15 the average grade of the bales sampled in North Carolina was slightly below Middling, although about 33⅓ per cent was Strict Middling or above. During 1915–16 the average grade was nearly Strict Middling, about 48 per cent being Strict Middling or above. This difference is accounted for by the better weather which prevailed during the latter picking season.

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[1] The authors desire to express their appreciation of the cooperation and assistance of the ginners, which contributed greatly to the success of this investigation. Mr. Fred Taylor, Cotton Technologist of the United States Department of Agriculture, supervised the study.

[2] The investigation in Edgecombe proving successful, the North Carolina Legislature passed a law (chap. 175, Public Laws, 1915) which authorizes county commissioners to employ county classers in cooperation with the North Carolina Agricultural Experiment Station, the United States Department of Agriculture, or both, acting together.

Only 2 per cent of the bales classed during the season of 1914–15 were less than ⅞ of an inch in length of staple; 61 per cent was ⅞ of an inch, and 37 per cent longer than ⅞ of an inch. The average length of staple for the samples taken during the season was approximately 0.90 inch. During the season 1915–16 (see Table I) approximately 3½ per cent of the bales classed were less than ⅞ of an inch in length of staple; 50 per cent were ⅞ of an inch, and 46½ per cent more than ⅞ of an inch. The average length of staple was approximately 0.92 inch. This longer length of staple shown for the season of 1915–16 is explained by the fact that samples were

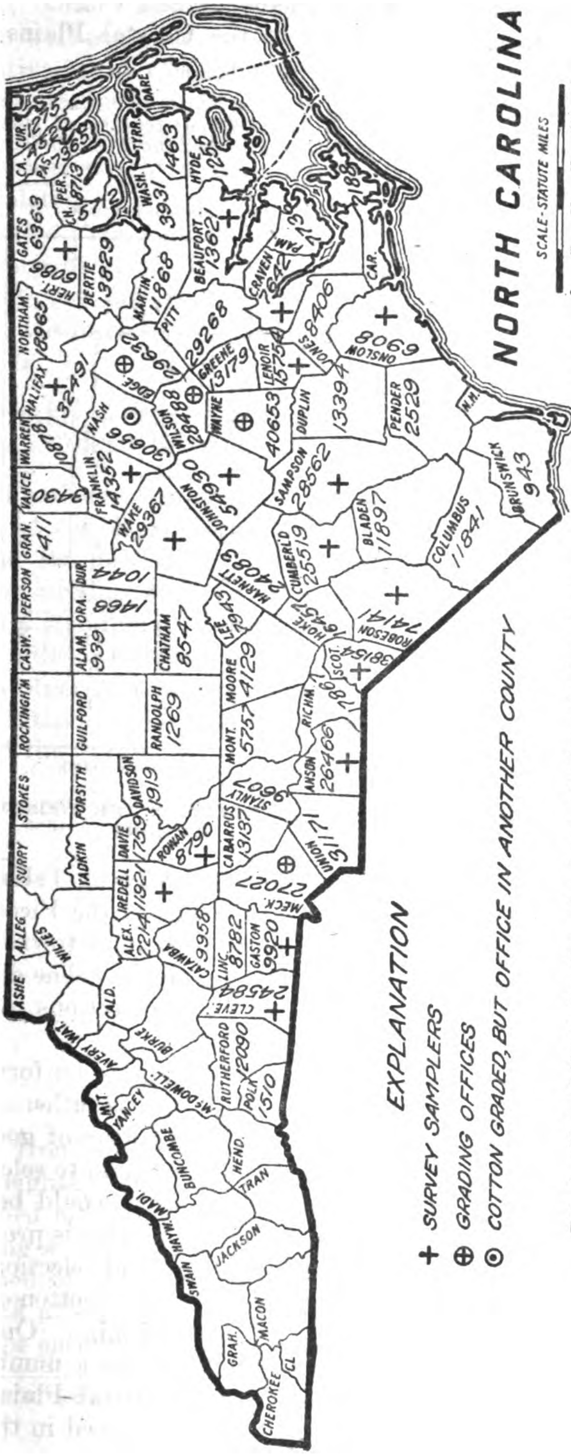

FIG. 1.—Map of North Carolina, showing production of bales of cotton by counties for 1914–15 season.

collected both in the Piedmont and Coastal Plains sections, while sampling was confined to the Coastal Plains during the 1914-15 season.

TABLE I.—*Percentages of the different lengths of staple of cotton sampled in each town during the 1915-16 season.*

| Market. | Length of staple in inches. | | | | | | | Section. | Average staple length. |
|---|---|---|---|---|---|---|---|---|---|
| | Less than ⅞. | ⅞ | $\frac{15}{16}$ | 1 | $1\frac{1}{16}$ | 1⅛ | $1\frac{3}{16}$ and longer. | | |
| | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | | |
| Ahoskie | 25 | 65 | 7 | 2 | 1 | | | Coastal | 0.86 |
| Charlotte | ½ | 36 | 15 | 38 | 4 | 4 | 2 | Piedmont. | .95 |
| Clinton | | ½ | 18 | 80 | 1½ | | | Coastal | 1.00 |
| Fayetteville | | 82 | 16 | 2 | | | | ...do | .875 |
| Gastonia | 1½ | 3 | 7 | 36 | 30 | 8 | 14 | Piedmont. | 1.06 |
| Goldsboro | 1 | 65 | 30 | 3½ | ½ | | | Coastal | .91 |
| Jacksonville | | 26 | 45½ | 26 | 2½ | | | ...do | .94 |
| Kings Mountain | | 1 | 2 | 43 | 50 | 3 | 1 | Piedmont. | 1.03 |
| Kinston | 2 | 21 | 35 | 37 | 3 | 1½ | | Coastal | .95 |
| Laurinburg | | 27 | 59 | 14 | | | | ...do | .94 |
| Louisburg | 1½ | 39 | 58 | 1 | | ½ | | Piedmont. | .94 |
| Nashville | 5 | 86 | 7½ | ½ | ½ | | ½ | Coastal | .875 |
| New Berne | ½ | 3 | 5 | 33 | 50 | 8 | ½ | ...do | .97 |
| Raleigh | | 42 | 48 | 10 | | | | Piedmont. | .94 |
| Red Springs | | 71 | 28½ | ½ | | | | Coastal | .875 |
| Salisbury | ½ | 30 | 62½ | 7½ | ½ | | | Piedmont. | .94 |
| Scotland Neck | 22 | 70 | 7½ | | | | ½ | Coastal | .875 |
| Selma | 2 | 35 | 50 | 13 | | | | ...do | .94 |
| Statesville | | 1 | 16 | 28 | 52 | 3 | | Piedmont. | 1.03 |
| Tarboro | 5 | 80 | 12 | 2 | | 1 | | Coastal | .88 |
| Wadesboro | | 1 | 7 | 60 | 31 | ½ | ½ | Piedmont. | 1.00 |
| Washington | | 31 | 33 | 32 | 3 | | | Coastal | .94 |
| Wilson | | 27 | 9 | 62 | 1½ | ½ | | ...do | .97 |

Total number of bales stapled for all the above towns, 25,020.

## COMPARISON OF COTTON PRODUCED IN THE PIEDMONT AND COASTAL PLAIN SECTIONS.

It will be observed from a study of Table I that although the samples of cotton from the towns of the Piedmont section have not in every case staple superior to that of towns in the Coastal Plain, as a class they do have a longer staple. The difference in the general character of the cotton of the two sections is marked and commercially recognized.

The cotton of the Coastal Plain is uniform in length of staple and is of good strength. Most of it is rather light in body, but there is a fair amount of heavy-bodied cotton of good quality. This indicates that, if proper attention were paid to selecting suitable varieties for planting, the value of the crop would be materially increased. Although some cotton of poor character is produced in the Piedmont section of the State, and more careful selection of the varieties to be planted would be amply rewarded, the cotton of the Piedmont section is superior to that of the Coastal Plains. One cause for this difference is due to the fact that there are a number of small, primitive plantation gins located in the Coastal Plain section of the State, and only about half the cotton produced in that section is ginned at large, modern custom gins, while the majority of the gins in the Piedmont section are well equipped.

There is less incentive in the Coastal Plain section to improve the character of the cotton produced since neither the length of staple of individual bales nor the average length of staple produced in a community seems to have any weight in determining the price paid for certain bales or the relative standing of the town as a cotton market. This is not true of the Piedmont section, as it appears that the length of staple of each bale and the average length of staple produced in a community are factors in determining both the prices of individual bales and the relatively higher prices paid at certain markets.

## PRODUCTION COMPARED WITH CONSUMPTION OF COTTON IN NORTH CAROLINA.

A matter worthy of serious consideration by buyers and consumers as well as producers of cotton in North Carolina is that, notwithstanding the fact that the mills of the State consume more cotton than is produced in it, production does not meet the peculiar needs of consumption from a standpoint of length of staple. (See Table II.) A survey of the mills of the State made by the Division of Markets of the North Carolina Agricultural Experiment Station shows that more than three-fifths of the cotton consumed in North Carolina is produced outside of the State.

TABLE II.—*Comparison of lengths of staple of cotton produced and consumed in North Carolina during the 1914–15 season.*

| | Length of staple in inches. | | | | |
|---|---|---|---|---|---|
| | Less than $\frac{7}{8}$. | $\frac{7}{8}$ | $\frac{15}{16}$ | 1 | $1\frac{1}{16}$ or longer. |
| | *Bales.* | *Bales.* | *Bales.* | *Bales.* | *Bales.* |
| Produced | 28,000 | 400,000 | 160,000 | 152,000 | 56,000 |
| Consumed | 27,000 | 300,000 | 180,000 | 234,000 | 144,000 |
| Overproduction | 1,000 | 100,000 | | | |
| Underproduction | | | 20,000 | 82,000 | 88,000 |

It will be observed from a study of Table II that while there is more cotton of seven-eighths of an inch and less in length of staple raised than is consumed or manufactured in the State, the reverse is true of cotton having a length of staple of 1 inch or more. This condition can be remedied if producers will give reasonable consideration to the length of staple when selecting varieties for planting.[1] Producers will be encouraged to grow cotton of a better staple if buyers will use proper discrimination in the prices paid for different lengths of staple. Production to meet the requirements of State consumption might enable the mills to secure their supplies more economically through the reduction of freight and other charges, which condition might result in turn in higher prices being paid locally for cotton.

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[1] Cook, O. F. The Relation of Cotton Buying to Cotton Growing. U. S. Department of Agriculture, Bulletin No. 60.

## RELATIVE MERITS OF CERTAIN PRIMARY MARKETS IN NORTH CAROLINA.

### COMPARISON OF PRIMARY MARKETS IN THE COASTAL PLAIN SECTION.

An effort was made to ascertain the relative importance of certain primary markets in the Coastal Plain section. In order to make the comparison as accurate as possible a record was made of prices received for unclassed cotton of the same grades on the same dates in any two of the markets. The resulting averages shown in Table III indicate accurately the differences in prices which existed in any two markets. The prices received in Fayetteville, for instance, averaged 11.64 cents for cotton of the same grades sold on the same dates which brought 11.67 cents in Ahoskie. Again, the prices received for cotton of the same grades sold on the same dates in Fayetteville and Clinton averaged 11.98 cents and 11.92 cents, respectively.

A study of this table shows that the average length of staple at a town has no apparent bearing upon its relative merit as a market. As an example, Ahoskie with an average length of staple of less than $\frac{7}{8}$ of an inch paid an average of 27 points, or $1.35 per bale, more than Clinton with an average length of staple of 1 inch.

Special attention is called to the statement for the town of New Berne in Table III and also in Table I. The fact that a superior staple is produced in that section evidently is not known to the producers and probably not to the local buyers, as the market averages low in price and no distinction is made between different lengths of staple. A study of the record slips showed that cotton only $\frac{7}{8}$ of an inch in length of staple in every instance brought as much as cotton $1\frac{1}{8}$ and $1\frac{3}{16}$ inches in length of staple, when as a matter of fact the difference in value is from $10 to $15 a bale.

From the standpoint of price the relative merits of these markets seemingly were: 1st, Fayetteville; 2d, Ahoskie; 3d, Kinston; 4th, Jacksonville; 5th, Selma, 6th, Clinton; 7th, New Berne; 8th, Laurinburg; 9th, Washington; 10th, Scotland Neck; and 11th, Red Springs.

TABLE III.—*Comparison of average price per pound received for unclassed cotton at primary markets in Coastal Plain section, season 1915–16, grade and date of sale coinciding.*

[Prices in boldface figures apply to towns in boldface type. Prices in lightface figures apply to towns in lightface type.]

| | Ahoskie. | Clinton. | Fayetteville. | Jacksonville. | Kinston. | Laurinburg. | New Berne. | Red Springs. | Scotland Neck. | Selma. | Washington. | Average. | Average length of staple. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *Cts.* | *In.* |
| **Ahoskie** | ......<br>...... | 11.03<br>**11.30** | 11.64<br>**11.67** | 11.52<br>**11.52** | 11.37<br>**11.27** | 11.01<br>**11.38** | 11.42<br>**11.39** | 10.93<br>**11.42** | 10.96<br>**11.30** | 11.67<br>**11.47** | 11.35<br>**11.42** | 11.29<br>**11.41** | ......<br>**0.860** |
| **Clinton** | 11.30<br>**11.03** | ......<br>...... | 11.98<br>**11.92** | 12.00<br>**11.91** | 11.44<br>**11.35** | 10.37<br>**10.67** | 11.51<br>**11.40** | 10.69<br>**11.20** | 11.04<br>**11.19** | 11.04<br>**11.25** | 11.75<br>**11.76** | 11.31<br>**11.36** | ......<br>**1.000** |
| **Fayetteville** | 11.67<br>**11.64** | 11.92<br>**11.98** | ......<br>...... | 10.96<br>**11.18** | 11.51<br>**11.63** | 10.91<br>**11.10** | 11.16<br>**11.36** | 10.80<br>**10.96** | 11.07<br>**11.36** | 10.76<br>**10.79** | 10.83<br>**11.13** | 11.15<br>**11.31** | ......<br>**.875** |
| **Jacksonville** | 11.52<br>**11.52** | 11.91<br>**12.00** | 11.18<br>**10.96** | ......<br>...... | 11.87<br>**11.71** | 11.08<br>**11.36** | 11.92<br>**12.00** | 10.88<br>**10.83** | 11.38<br>**11.55** | 10.41<br>**10.38** | 11.68<br>**11.81** | 11.31<br>**11.41** | ......<br>**.940** |
| **Kinston** | 11.27<br>**11.37** | 11.35<br>**11.44** | 11.63<br>**11.51** | 11.71<br>**11.87** | ......<br>...... | 10.81<br>**10.89** | 11.27<br>**11.38** | 11.16<br>**11.58** | 10.91<br>**11.23** | 11.32<br>**11.25** | 11.27<br>**11.44** | 11.27<br>**11.39** | ......<br>**.950** |
| **Laurinburg** | 11.38<br>**11.01** | 10.67<br>**10.37** | 11.10<br>**10.91** | 11.36<br>**11.08** | 10.89<br>**10.81** | ......<br>...... | 10.72<br>**10.87** | 10.88<br>**10.88** | 10.80<br>**10.72** | 11.07<br>**10.99** | 10.39<br>**11.16** | 10.92<br>**10.88** | ......<br>**.940** |
| **New Berne** | 11.39<br>**11.42** | 11.40<br>**11.51** | 11.36<br>**11.16** | 12.00<br>**11.92** | 11.38<br>**11.27** | 10.87<br>**10.72** | ......<br>...... | 11.10<br>**11.44** | 11.12<br>**11.34** | 11.12<br>**10.95** | 11.22<br>**11.25** | 11.29<br>**11.29** | ......<br>**.970** |
| **Red Springs** | 11.42<br>**10.93** | 11.20<br>**10.69** | 10.96<br>**10.80** | 10.83<br>**10.88** | 11.58<br>**11.16** | 10.88<br>**10.88** | 11.44<br>**11.10** | ......<br>...... | 10.94<br>**10.78** | 11.20<br>**10.91** | 11.05<br>**11.06** | 11.15<br>**10.91** | ......<br>**.875** |
| **Scotland Neck** | 11.30<br>**10.96** | 11.19<br>**11.04** | 11.36<br>**11.07** | 11.55<br>**11.38** | 11.23<br>**10.91** | 10.72<br>**10.80** | 11.34<br>**11.12** | 10.78<br>**10.94** | ......<br>...... | 11.28<br>**10.92** | 11.23<br>**10.96** | 11.19<br>**11.01** | ......<br>**.875** |
| **Selma** | 11.47<br>**11.67** | 11.25<br>**11.04** | 10.79<br>**10.76** | 10.38<br>**10.41** | 11.25<br>**11.32** | 10.99<br>**11.07** | 10.95<br>**11.12** | 10.91<br>**11.20** | 10.92<br>**11.28** | ......<br>...... | 11.02<br>**11.25** | 10.99<br>**11.11** | ......<br>**.940** |
| **Washington** | 11.42<br>**11.35** | 11.76<br>**11.75** | 11.13<br>**10.83** | 11.81<br>**11.68** | 11.44<br>**11.27** | 11.16<br>**10.39** | 11.25<br>**11.22** | 11.06<br>**11.05** | 10.96<br>**11.23** | 11.25<br>**11.02** | ......<br>...... | 11.32<br>**11.17** | ......<br>**.940** |

### COMPARISON OF PRIMARY MARKETS IN THE PIEDMONT SECTION.

A comparison of the average prices paid for the same grades of cotton on the same dates at certain towns in the Piedmont section is given in Table IV.

Attention is called to the fact that with the exception of Salisbury as compared with Statesville the markets compared as to prices in direct ratio to their average length of staple. A possible explanation of this exception is that there are supply merchants who buy cotton at Salisbury, while such is not the case at Statesville.

From the standpoint of price the relative merits of these markets seemingly were: First, Gastonia; second, Kings Mountain; third, Wadesboro; fourth, Salisbury; fifth, Statesville; sixth, Raleigh; and seventh, Louisburg.

TABLE IV.—*Comparison of average price per pound received for unclassed cotton at primary markets in Piedmont section during the 1915–16 season, grade and date of sale coinciding.*

[Prices in boldface figures apply to towns in boldface type. Prices in lightface figures apply to towns in lightface type.]

| | Gastonia. | Kings Mountain. | Louisburg. | Raleigh. | Salisbury. | Statesville. | Wadesboro. | Average. | Average length of staple. |
|---|---|---|---|---|---|---|---|---|---|
| | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Inches.* |
| **Gastonia** | ........<br>........ | 12.03<br>**12.69** | 11.79<br>**12.66** | 11.64<br>**12.79** | 11.68<br>**12.65** | 11.75<br>**12.73** | 11.81<br>**12.42** | 11.61<br>**12.65** | ........<br>**1.06** |
| **Kings Mountain** | 12.69<br>**12.03** | ........<br>........ | 11.69<br>**12.16** | 11.72<br>**11.95** | 11.88<br>**12.02** | 11.74<br>**11.73** | 11.74<br>**12.15** | 11.91<br>**12.00** | ........<br>**1.06** |
| **Louisburg** | 12.66<br>**11.79** | 12.16<br>**11.69** | ........<br>........ | 11.52<br>**11.50** | 11.94<br>**11.68** | 11.58<br>**11.56** | 11.81<br>**11.85** | 11.94<br>**11.68** | ........<br>**.94** |
| **Raleigh** | 12.79<br>**11.64** | 11.95<br>**11.72** | 11.50<br>**11.52** | ........<br>........ | 11.73<br>**11.55** | 11.45<br>**11.50** | 11.72<br>**11.68** | 11.85<br>**11.60** | ........<br>**.94** |
| **Salisbury** | 12.65<br>**11.78** | 12.02<br>**11.88** | 11.68<br>**11.94** | 11.55<br>**11.73** | ........<br>........ | 11.57<br>**11.78** | 11.81<br>**11.71** | 11.88<br>**11.78** | ........<br>**.94** |
| **Statesville** | 12.73<br>**11.75** | 11.73<br>**11.74** | 11.56<br>**11.58** | 11.50<br>**11.45** | 11.78<br>**11.57** | ........<br>........ | 11.85<br>**11.82** | 11.86<br>**11.65** | ........<br>**1.03** |
| **Wadesboro** | 12.42<br>**11.81** | 12.15<br>**11.74** | 11.85<br>**11.81** | 11.68<br>**11.72** | 11.71<br>**11.81** | 11.82<br>**11.85** | ........<br>........ | 11.94<br>**11.96** | ........<br>**1.00** |

## COMPARISON OF PIEDMONT SECTION WITH THE COASTAL PLAIN SECTION.

A comparison of the last two columns of Tables III and IV shows that cotton produced in the Coastal Plain did not bring as high average prices as cotton of the same length of staple produced in the Piedmont section. This difference may be accounted for, in part, by the better body of the cotton produced in the Piedmont section, but the difference in value between the types of cotton produced in the two sections is not sufficient to account for all of this difference. A probable reason is that more careful recognition is given to the class of individual bales in the Piedmont section than in the Coastal Plain section.

The fact that producers are able to secure premiums for bales of superior grades and staples in the Piedmont section seems to be a sufficient reason to account for the greater care that is exercised in the picking and handling of the cotton produced in that section, as evidenced by the much higher average grade. Furthermore, it seems evident that the failure of buyers in the Coastal Plain section to give producers premiums for superior cottons has had a deleterious effect upon the cotton produced. In the Coastal Plains cotton is bought according to a system of averages, while in the Piedmont section reasonable consideration is given to the class of individual bales.

## COMPARISON OF CASH WITH CREDIT SALES.

The average prices for cash sales and for sales which are credited to the owner's account by a merchant, as tabulated by the department, showed a seeming advantage for credit sales of about 15 points, or 75 cents per bale. It is generally conceded that a merchant who does not depend upon the handling of cotton for a livelihood, but who uses it to collect accounts and induce trade, will handle cotton for the mere cost, sometimes even at a loss.

Important facts in this study were developed from an examination of the individual sales. While the majority of credit sales were slightly higher than average cash sales for the same grades, the range between high and low prices was much greater for sales on account than for cash sales. A number of credit sales were materially higher than cash sales, but some credit sales were much lower than the average cash sales. This indicates that the financial condition of the seller enters into sales on account. The highest price seemingly is paid to those who have no security except their cotton. Such parties frequently are charged a higher price for supplies that they purchase. Therefore, the higher price paid for cotton, the proceeds from which are credited to their account, is in a large measure, if not entirely, offset by the higher prices charged for merchandise.

## PRICES RECEIVED FOR CLASSED COTTON COMPARED WITH PRICES RECEIVED FOR UNCLASSED COTTON.

### COASTAL PLAIN SECTION.

A comparison of the average prices paid for cotton of the same grades sold on the same dates during the 1914–15 season in Tarboro, Edgecombe County, where it was classed, and three other towns in the Coastal Plain section where it was unclassed is shown in Table V. It will be noted that the cotton classed before sale brought an average of 18 points, or $0.90 per bale, more than did the unclassed cotton sold on the same dates at Fayetteville, Goldsboro, and Scotland Neck. Upon this basis the farmers of Edgecombe County, as a direct result of the grading service rendered them, received about $12,000 more than they otherwise would have received for the season's crop.

**Table V.**—*Comparison of average prices per pound received for classed and unclassed cotton of the same grades sold on the same dates during the 1914–15 season.*

[Prices in boldface figures apply to town in boldface type. Prices in lightface figures apply to towns in lightface type.]

| Market selling classed cotton. | Markets selling unclassed cotton. | | | Average. |
|---|---|---|---|---|
| | Fayetteville. | Goldsboro. | Scotland Neck. | |
| | *Cents.* | *Cents.* | *Cents.* | *Cents.* |
| **Tarboro** | 6.98<br>**7.15** | 7.04<br>**7.19** | 6.77<br>**6.99** | 6.93<br>**7.11** |
| Difference in price | .17 | .15 | .22 | .18 |

**Table VI.**—*Comparison of average prices per pound received for classed cotton and unclassed cotton of the same grades on the same days in the Coastal Plain section, 1915–16 season.*

[Prices in boldface figures apply to town in boldface type. Prices in lightface figures apply to towns in lightface figures.]

| Markets selling classed cotton. | Markets selling unclassed cotton. | | | | | | | | | | | Average. | Average length of staple. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ahoskie. | Clinton. | Fayetteville. | Jacksonville. | Kinston. | Laurinburg. | New Berne. | Red Springs. | Scotland Neck. | Selma. | Washington. | | |
| | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Inches* |
| **Goldsboro** | 11.32<br>**11.40** | 11.11<br>**11.51** | 11.43<br>**11.52** | 11.75<br>**12.15** | 11.57<br>**11.69** | 9.75<br>**11.00** | 11.32<br>**11.80** | 10.63<br>**11.48** | 10.91<br>**11.54** | 11.00<br>**12.00** | 11.56<br>**12.00** | 11.12<br>**11.64** | **0.91** |
| **Tarboro** | 11.41<br>**11.29** | 11.34<br>**11.40** | 11.28<br>**11.27** | 11.35<br>**11.30** | 11.48<br>**11.44** | 11.21<br>**11.26** | 11.46<br>**11.37** | 10.71<br>**11.10** | 10.90<br>**11.12** | 11.21<br>**11.10** | 10.89<br>**11.26** | 11.22<br>**11.27** | **.88** |
| **Wilson** | 11.41<br>**11.68** | 11.36<br>**11.52** | 11.50<br>**11.81** | 11.78<br>**12.04** | 11.53<br>**11.57** | 10.97<br>**11.60** | 11.60<br>**11.64** | 10.61<br>**11.55** | 11.00<br>**11.45** | 11.66<br>**11.54** | 11.22<br>**11.95** | 11.33<br>**11.66** | **.97** |
| Average difference in prices between each town and Goldsboro, Tarboro, and Wilson | −.06 | −.20 | −.13 | −.21 | −.08 | −.64 | −.14 | −.72 | −.44 | −.18 | −.51 | −.30 | [a].92 |
| Average of length staple (inches). | .86 | 1.00 | .875 | .94 | .95 | .94 | .97 | .875 | .875 | .94 | .94 | [a].93 | ...... |

[a] General average.

During the 1915–16 season the service rendered at Tarboro was extended to Goldsboro and Wilson, in the Coastal Plain section, with the result that at the towns where cotton was classed before sale a higher average price was received than in towns where the cotton was unclassed. Table VI gives a comparison of prices received for cotton that was classed before sale as compared with prices received for unclassed cotton in certain towns during this season. Prices received in the three towns where classing work was done averaged 30 points, or $1.50 per bale, higher than prices received in the 11 towns at which cotton was not classed before sale. Furthermore, not a single town in which unclassed cotton was sold shows a higher average price than the average price for the same grades and dates in the three towns where classed cotton was sold. It will be observed that the average length of staple of cotton sold in towns where it was classed for producers is slightly less than the average length of staple where unclassed cotton was sold.

Special attention is called to Goldsboro as compared with Tarboro for the season 1914–15, in Table V. In this table Tarboro with classed cotton averages 15 points higher, or 75 cents per bale more than Goldsboro with unclassed cotton. A comparison of all sales on coinciding grades and dates for classed cotton during the 1915–16 season shows that the classed cotton sold at Goldsboro averaged 10 points higher than classed cotton sold at Tarboro. This indicates a net gain of 25 points, or $1.25 per bale, for classed cotton as compared with unclassed cotton sold in the same town.

Using the figures given in this table as a basis of comparison, it appears that had all the cotton produced in the Coastal Plain section been classed before sale the producers would have received approximately $1.50 per bale, or about $800,000, more than actually was received.

### PIEDMONT SECTION.

The prices received for cotton classed before sale at Charlotte compared with prices received for unclassed cotton of the same grades sold on the same dates at other towns in the Piedmont section during the 1915–16 season are shown in Table VII. Classed cotton sold at Charlotte brought an average of 6 points, or 30 cents per bale, more than unclassed cotton sold at the other seven towns, notwithstanding the fact that the average length of staple of the cotton classed before sale was only 0.95 inch and the average length of staple of the unclassed cotton was 0.99 inch.

TABLE VII.—*Comparison of average price received for classed cotton and unclassed cotton of the same grades sold on the same days at towns in the Piedmont section during 1915–16 season.*

[Prices in boldface figures apply to town in boldface type. Prices in lightface figures apply to town in lightface type.]

| Market selling classed cotton. | Markets selling unclassed cotton. | | | | | | | Average. | Average length of staple. |
|---|---|---|---|---|---|---|---|---|---|
| | Gastonia. | Kings Mountain. | Louisburg. | Raleigh. | Salisbury. | Statesville. | Wadesboro. | | |
| | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Inches.* |
| **Charlotte** | 12.03<br>**11.80** | 11.92<br>**11.92** | 11.58<br>**11.87** | 11.80<br>**12.02** | 12.11<br>**12.06** | 11.83<br>**11.85** | 11.68<br>**11.92** | 11.85<br>**11.91** | 1.00<br>**.95** |
| **Length of staple in each town.** | 1.06 | 1.03 | .94 | .94 | .94 | 1.03 | 1.00 | ........ | ....... |

Special attention is called to Gastonia as compared with Charlotte. The average price for unclassed cotton sold at Gastonia was 12.03 cents, while it was only 11.80 cents for the classed cotton sold at Charlotte. It will be observed, however, that the average length of staple at Gastonia was 1.06 inches, whereas the average length of staple at Charlotte was only 0.95, a difference of approximately one-eighth of an inch. While unclassed cotton sold at Gastonia brought 23 points, or $1.15 per bale, more than classed cotton sold at Charlotte, the real difference in value of the cotton was at least 60 points, or $3 per bale, more for the Gastonia cotton on account of the length of staple. This indicates that in this instance the cotton classed before sale brought $1.85 per bale more than the unclassed cotton, value being considered.

The cotton sold at Salisbury was not of greater value than that sold at Charlotte, but the fact that such a large portion of the cotton sold at Salisbury is purchased by supply merchants is believed to account for the consistent showing it made in this and other tables as a high market.

As there are about 300,000 bales produced in this section, Table VII indicates that at least $90,000 might have been saved the farmers of the Piedmont section had their cotton been classed before sale. Because of the inferior staple sold at Charlotte as compared with that sold at the other towns, it might be assumed that the producers of this section would have received $175,000 to $200,000 more for their cotton by having it classed before sale.

### DIFFERENCE IN PRICES BETWEEN GRADES.

A comparison of the average difference in prices between grades on classed and unclassed cotton sold during the 1915–16 season is shown in Table VIII. These data were compiled in order to ascertain whether individual bales brought more nearly what they were worth if the owner were informed of the grade of the bale before sale. The information was obtained by finding the average price at which each grade sold at each town throughout the same period of time and determining the difference between these average prices.

It will be noted that the differences on grades below Middling were more favorable to the seller of unclassed cotton than to the seller of classed cotton. On the other hand, differences on grades above Middling were more favorable to the seller of cotton that had been classed before sale. Taking into consideration the fact that 48 per cent of the cotton was above Middling and only 27½ per cent below Middling, it will be seen that the differences used on classed cotton were more favorable to the seller than the differences used on unclassed cotton.

**TABLE VIII.**—*The average differences in price between grades of unclassed cotton during 1915–16 season.*

| Markets selling unclassed cotton. | Good ordinary. | Strict good ordinary. | Low middling. | Strict low middling. | Middling. | Strict middling. | Good middling. | Strict good middling. | Section. |
|---|---|---|---|---|---|---|---|---|---|
| | Average differences quoted at Norfolk, Va. | | | | | | | | |
| | *Points.*<br>200 off | *Points.*<br>150 off | *Points.*<br>100 off | *Points.*<br>37½ off | 0 | *Points.*<br>25 on | *Points.*<br>50 on | *Points.*<br>75 on | |
| Aboskie | ........ | ........ | 7 off | 5 off | 0 | 7 on | 11 on | 29 off | Coastal. |
| Charlotte | ........ | ........ | ........ | ........ | 0 | 19 on | 26 on | 80 on | Piedmont. |
| Clinton | ........ | ........ | 38 off | 53 off | 0 | 14 on | 20 on | 15 on | Coastal. |
| Fayetteville | ........ | ........ | 64 off | 27 on | 0 | 11 on | 20 on | ........ | Do. |
| Gastonia | ........ | ........ | ........ | ........ | 0 | 1 on | 35 on | 47 on | Piedmont. |
| Goldsboro | ........ | ........ | 17 off | 10 off | 0 | 14 on | 16 on | ........ | Coastal. |
| Jacksonville | ........ | 45 off | 15 off | 2 on | 0 | 1 on | 11 on | 13 on | Do. |
| Kings Mountain | ........ | ........ | ........ | 5 off | 0 | 17 off | 16 off | 16 off | Piedmont. |
| Kinston | 204 off | 70 off | 54 off | 16 off | 0 | 5 on | 11 on | 4 off | Coastal. |
| Laurinburg | 69 off | 49 off | 34 off | 4 on | 0 | 15 on | 18 on | ........ | Do. |
| Louisburg | ........ | ........ | 39 off | 4 on | 0 | 6 off | 6 off | 7 off | Piedmont. |
| New Berne | ........ | ........ | ........ | 26 off | 0 | 3 on | 7 on | 5 on | Coastal. |
| Raleigh | ........ | ........ | 50 off | 56 off | 0 | 35 off | 36 off | 77 off | Piedmont. |
| Red Springs | 45 off | 14 off | 4 off | 3 on | 0 | 9 off | 4 off | ........ | Coastal. |
| Salisbury | ........ | ........ | ........ | 4 on | 0 | 14 off | 6 on | 23 off | Piedmont. |
| Scotland Neck | ........ | 79 off | 52 off | 35 off | 0 | 14 on | 33 on | ........ | Coastal. |
| Selma | ........ | ........ | 10 off | 10 off | 0 | 25 on | 25 on | 34 on | Do. |
| Statesville | ........ | ........ | 1 off | ........ | 0 | 5 on | 31 off | 37 on | Piedmont. |
| Wadesboro | 120 off | 27 off | 46 off | 10 off | 0 | 11 on | 13 on | 15 on | Do. |
| Washington | ........ | 168 off | 1 off | ........ | 0 | 6 on | 9 off | ........ | Coastal. |
| Average differences used on unclassed cotton. | 128 off | 84 off | 52 off | 21 off | 0 | 3 on | 7 on | 12 on | |
| Average differences used on classed cotton at Charlotte, Goldsboro, Tarboro, and Wilson. | 196 off | 123 off | 58 off | 23 off | 0 | 22 on | 34 on | 38 on | |
| Per cent of each grade in State. | 1 | 3½ | 8 | 15 | 25 | 29 | 15 | 4 | |

Failure to make proper differences between grades in the purchase of unclassed cotton is not confined to any section of the State. However, a study of Table VIII reveals the fact that, as a rule, in the Piedmont section insufficient premiums are paid for the grades above Middling, while in the Coastal Plain section the differences on grades above Middling are more nearly correcct. This fact seems to indicate, and personal investigation has confirmed this belief, that while approximately correct differences may be used by buyers in the purchase of grades that are not sold in quantity at a town, differences favorable to the purchaser are used if the grade is produced in quantity.

An example of the abuses which the classing service might hope to correct was observed in Mecklenburg County. Among the samples received from a certain gin all the cotton belonging to one producer was 1¼ inches in length of staple. With the aid of his class cards this producer disposed of his cotton for 16 cents per pound. He stated that he had been producing 15 to 20 bales per year of the same variety of cotton for five or six years and that while he thought that his cotton had good staple, he never before had received more than the ordinary short-staple price. This producer received about $20 a bale more than he would if his cotton had not been classed, amounting to about $400 for his entire crop. At this rate he has suffered a total loss of about $2,000 during the last five years by not knowing the class of his cotton. While this case is probably exceptional, it indicates the possible loss to the farmer of not knowing the class of his cotton.

It may be concluded, therefore, that the higher prices that many producers were able to secure for cotton that had been classed, as compared with unclassed cotton, were largely due to the application of differences that were approximately correct. Were there no economic gain to the producers as a whole in having cotton classed before sale the fact that many individuals would secure more nearly that to which they are justly entitled is ample reason for rendering classing service.

### COMPARISON OF SALES MADE AT PRIMARY MARKETS WITH SALES MADE AT NORFOLK, VA.

Considerable cotton is shipped by producers in the eastern part of North Carolina to Norfolk, Va., to be sold there by brokers, and data were received and compiled for about 1,000 bales of classed cotton sold there.

The data for the 1914–15 season tabulated by the department show that the average price received for cotton sold at Norfolk was 7.09 cents, while the average price at which the same grades were sold on the same dates at Fayetteville, Scotland Neck, and Tarboro was 6.56 cents, a difference of 53 points, which was partly offset by an average freight rate of 28⅓ points, leaving a net discrepancy of 24 points.

A similar comparison is shown in Table IX for the 1915–16 season for all of the towns from which data were secured, covering coinciding grade and date sales. This table shows an average difference in favor of Norfolk of 43 points, which is subject to a deduction on account of freight rates of 32 points, leaving a net difference of 11 points.

TABLE IX.—*Average prices received for the same grades of cotton on the same dates in North Carolina primary markets and Norfolk, Va., 1915–16 season.*

[Prices in boldface figures apply to town in boldface type. Prices in lightface figures apply to towns in lightface type.]

| | Ahoskie. | Clinton. | Fayetteville. | Jacksonville. | Kinston. | Laurinburg. | Red Springs. | Scotland Neck. | Tarboro. | Average. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* |
| **Norfolk** | 11.59<br>**11.84** | 11.63<br>**12.00** | 12.00<br>**11.50** | 11.55<br>**12.01** | 12.50<br>**12.13** | 11.07<br>**11.83** | 10.35<br>**11.91** | 11.33<br>**11.96** | 10.88<br>**11.54** | 11.43<br>**11.86** |

TABLE X.—*Current freight rates on cotton, uncompressed, in cents per 100 pounds, July 19, 1916.*

| From— | To— | | | | |
|---|---|---|---|---|---|
| | Norfolk, Va. | Wilmington, N. C. | Greensboro, N. C. | Charlotte, N. C. | Charleston, S. C. |
| | *Cents.* | *Cents.* | *Cents.* | *Cents.* | *Cents.* |
| Ahoskie | 20 | 30 | 37 | 40 | 45 |
| Charlotte | 44 | 34 | 25 | ........ | 44 |
| Clarkton | 40 | 18 | 36 | 30 | 40 |
| Clinton | 39 | 31 | 34 | 39 | 40 |
| Fayetteville | 40 | 24 | 26 | 30 | 32 |
| Gastonia | 48 | 35¼ | 27 | 13 | 51 |
| Goldsboro | 27 | 33¼ | 28 | 40 | 40 |
| Jacksonvillle | 35 | [a] 75 | 38 | 38 | 40 |
| Kings Mountain | 48 | 51 | 38 | 16 | 51 |
| Kinston | 25 | 25 | 30 | 39¾ | 45 |
| Laurinburg | 40 | 28 | 32¼ | 24 | 35 |
| Louisburg | 39 | 40 | 29¼ | 37 | ........ |
| Nashville | 30 | 28 | 32 | 38 | 45 |
| New Berne | 17 | 17 | 35 | 40 | 45 |
| Raeford | 42 | 29 | 39.45 | 31.2 | 42 |
| Raleigh | 39 | 32 | 28 | 33 | 46 |
| Red Springs | 40 | 26 | 29 | 27 | 31 |
| Salisbury | 44 | 44 | 19 | 18 | 44 |
| Scotland Neck | 25 | 26½ | 34 | 39 | 45 |
| Selma | 39 | 26 | 26 | 36 | 40 |
| Statesville | 44 | 44 | 23 | 18 | 51 |
| Tarboro | 20 | 20 | 33 | 38 | 45 |
| Wadesboro | 44 | 29 | 33 | 19 | 31 |
| Washington | 17 | 19 | 37 | 40 | 45 |
| Wilson | 27 | 25½ | 30 | 37 | 40 |

[a] Applies per bale of 500 pounds or less; bales weighing over 500 pounds will be charged for in proportion.

The freight rates from all the primary markets studied in this investigation to Norfolk, Va., and all other concentration points affecting these markets are given in Table X. Considering the fact that those points having the highest freight rates are nearer to markets other than Norfolk and in practically all cases ship to them, there appears to be an advantage of about $1 per bale, after deducting brokerage and other charges in shipping to Norfolk.

A comparison of all sales of cotton classed for producers, made in Norfolk during the seasons of 1914–15 and 1915–16, with the quotations of that market for the dates on which these sales were made, shows that actual sales made at that point were uniformly about 11 points higher than the quotations. However, the figures do not in every instance show that the basis price on sales was higher than the quotations, but that frequently the price was raised by the use of better differences than those quoted.

Indiscriminate shipping to Norfolk is not recommended, as it probably would not be profitable unless the farmer knew the class of his cotton. Farmers who knew the class of their cotton and shipped to Norfolk were fortunate in the sale of their cotton. Since this city quotes what is supposed to be the daily prevailing price, the shippers were able to refuse offers which they knew were not in accordance with current quotations. As an example, one farmer who had class cards shipped 45 bales to a broker, with instructions that offers be submitted to him before the sale was made. The broker called him on the telephone late one afternoon, after all exchanges had closed, and advised that he was offered 7⅝ cents a pound for the lot. The farmer told the broker that he knew the lot would run a few points on Middling and that as the market was quoting Middling at 8 cents he felt that he should at least receive that price. The next morning the farmer received a check covering the sale of the cotton at 8 cents. Thus a difference of about $1.88 per bale, or $85 for the lot, was obtained which undoubtedly would have been lost to this farmer if he had not been informed as to the class of his cotton.

## COMPARISON OF SMALL AND LARGE LOT SALES.

A study of all comparable large and small lot sales shows that the producers who sold in large lots secured higher prices than the producers who sold only one or two bales at a time. For the season of 1914–15 a comparison of prices received for lots containing 10 or more bales with the average price received for single bales of the same grades sold on the same date shows an average difference in favor of the larger lots of 29 points, or $1.45 per bale. Sixteen large lots, comprising 867 bales, were used in this comparison, the lots ranging from 10 to 168 bales.

For the 1915–16 season a comparison of lots ranging from 20 to 159 bales showed a difference of 17½ points, or $0.85, per bale for the larger lots. The data compiled showed that there was no appreciable difference in prices between the sale of 20-bale lots and those containing 50 or more.

There seem to be two principal reasons for the increased price which large lots usually bring, one being the natural tendency of the buyer to grade the large lot carefully and buy it at a smaller profit per bale than he would the single bales, and the other being the inducement to the large producer, if he did not receive an offer in keeping with his grades, to ship his cotton to a point where he could obtain competitive offers. Such an opportunity is not usually open to the man with one or two bales.

It appears conclusive, therefore, that there is a material advantage in selling in reasonably large lots. This fact should be borne in mind by cotton producers, as an increased price generally can be secured without serious inconvenience to individuals. Cooperative selling organizations will best meet this need and are recommended. However, farmers who are unable to perfect organizations of this character in their neighborhood can undoubtedly secure higher prices merely by selling together.

## OTHER ADVANTAGES DERIVED FROM A KNOWLEDGE OF CLASS.

Among the other advantages derived from a definite knowledge of grade before sale it was observed that such knowledge was of considerable importance in settlements between landlords and tenants, in that it formed an equitable basis for adjustment when the rent notes called for a certain number of pounds of a designated grade. Merchants who had not handled sufficient cotton to become proficient classers were able to use the class cards to advantage in the purchase and sale of cotton.

Data compiled indicated that at markets where classed cotton was sold the price of unclassed cotton was approximately 10 points, or 50 cents, per bale higher than it was in markets where no classing was done. This fact has an important bearing upon the amount of money that has been saved to the cotton producers of North Carolina during the seasons of 1914–15 and 1915–16.

## CONCLUSIONS.

The samples of cotton which were graded and stapled during the 1914–15 and 1915–16 seasons showed an average grade for the two seasons of slightly above Middling. The use of more modern gins, especially in the Coastal Plain section, would raise the average grade produced in the State. The fact that only 3½ per cent of the cotton in the bales sampled was less than ⅞ of an inch in length of staple should be of great importance, since according to the United States cotton futures act ⅞ of an inch is the shortest length tenderable on future contracts.

The producers of North Carolina are not securing the advantage that proximity to the mills should give, through failure to produce the lengths of staple required by them. Care in selecting varieties for planting tends to improve this situation.

Marketing conditions on the whole are better in the Piedmont than in the Coastal Plain section. The grade and staple of individual bales are given reasonable consideration in the purchase of cotton in the Piedmont section, although inadequate premiums are paid for the higher grades. In the Coastal Plain section practically no distinction in price is made by the buyers between bales of different lengths of staple.

Sales made for the purpose of settling accounts are at a higher rate than are cash sales on coinciding dates and grades. The range of prices for credit sales is greater than the range of prices for cash sales. As a rule, however, this is not the economic gain that it appears, as the fact undoubtedly is taken into consideration in setting the price at which the goods, represented by the account, are sold.

It appears from the investigation that the average producer who knew the class of his cotton obtained about $1.15 per bale more than the farmer who was not furnished such information. Should this hold true for the whole crop, the producers of North Carolina would save over a million dollars by having their cotton classed before they sell it. Counties which produce five thousand or more bales would probably find it practicable and financially worth while to take advantage of benefits of the State grading law referred to in the footnote on page 2.

The relative value of different grades and lengths of staple is more nearly approximated in the sale of cotton, the class of which is known to the producer, than in the sale of unclassed cotton. It is reasonable to suppose that when the farmer is assured that his cotton is accurately and impartially classed and bought as classed, he will appreciate the advantage of exercising greater care in choosing the variety to be planted and also more care in the picking and handling in order to improve the grade and staple so that he may receive the premium which the superior product will bring.

Producers who sold in lots containing ten or more bales obtained from 88 cents to $1.45 per bale more than the producers who sold one or two bales. Classing is only the first step and pooling or selling organizations should be formed if the full benefits of classing are to be realized.

Norfolk, Va., seems an advantageous market for certain towns in eastern North Carolina, provided the shipper knows the class of his cotton. If the farmer does not know the value of his product, he is not only incompetent to dispose of it locally in an intelligent manner but is also unable to tell whether he is receiving full value if he sells it at a distant market.

Accurate knowledge of the grade of bales enables merchants who buy cotton in settlement of accounts to pay the individual farmer more nearly what his particular cotton is worth and to secure better prices for themselves when selling.

The sale of classed cotton at a primary market increased the price paid for unclassed cotton sold at that market about 10 points, or 50 cents per bale.

Investigations conducted in Arkansas by the Office of Markets and Rural Organization during the 1913–14, 1914–15, and 1915–16 seasons corroborate the conclusions drawn in this bulletin as to the value of a knowledge of the class of cotton before sale and the advantages derived from selling in large lots.

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CHARLES J. BRAND, Chief

Washington, D. C. ▼ April 2, 1917

# MARKETING AND DISTRIBUTION OF STRAWBERRIES IN 1915

By

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**BULLETIN No. 477**

**Contribution from the Office of Markets and Rural Organization**

**CHARLES J. BRAND, Chief**

**Washington, D. C.** ▼ **April 2, 1917**

# MARKETING AND DISTRIBUTION OF STRAWBERRIES IN 1915.

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## INTRODUCTION.

During the season of 1915 the Office of Markets and Rural Organization of the Department of Agriculture conducted an experimental market news service for strawberries, tomatoes, muskmelons, and peaches. This involved securing telegraphic reports of shipments of these products from all originating common carriers, and reliable reports of arrivals and prices of these products on the principal markets. This information was distributed free to growers and shippers by mail or by wire "collect" as desired.

In connection with this service, extensive surveys were made of the principal shipping areas of each of these crops and a representative of the office was stationed in one or more of the centers of production of each during the commercial movement to distribute direct to the producers all the market news at the command of the department.

The text of this bulletin is based upon observations made by the authors at shipping points, and by members of the staff working in the markets. The charts showing distribution are based upon reports furnished by wire during the shipping season by the railroads and boat lines handling important carload movements.

The tabulation of shipments by stations is compiled from the records of the various carriers as transmitted to the department at

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NOTE.—This bulletin is of interest to strawberry growers, shippers, transportation companies, and consumers, and to all engaged in the trade in berries and fruits.

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the end of the season and is admittedly somewhat incomplete. It includes practically no shipments of less than full carloads and in many cases the exact records of the business of certain stations could not be obtained. Only a few carriers of importance in the interstate shipment of strawberries have failed to make any report of their business. The figures on pages 27 to 32 are therefore fairly comparable with those for 1914, published in Department Bulletin 237.[1]

An exception should perhaps be made in the cases of California and Washington, for later information leads to the belief that a number of the cars reported shipped from stations in these States in 1914 were probably less than carload shipments. Furthermore, the movement from one important section of California was largely by boat in 1915 and no record has been obtained, whereas this area furnished a large part of the movement as reported by the railroads in 1914. The berries handled by electric lines which do not move in standard carloads also constitute an element of uncertainty.

## METHODS EMPLOYED IN DEALING WITH STRAWBERRY PICKERS.

As the shipment of strawberries over long distances has developed to the proportions of an important specialized industry, the problems of marketing have grown in number and complexity. Satisfactory quality on arrival in the distant market is impossible without a well-organized picking force of sufficient size to gather daily the berries which are ready for shipment. Irregularity in picking is almost sure to result in the shipment of many overripe berries, which cause serious deterioration before they reach the consumer.

The demand for pickers is so great in some sections that large numbers of pickers are brought in for the season. A few rainy days after the height of the picking is reached at a specific point may cause a migration of pickers to points farther north, thus curtailing the total output of a large shipping area. Serious losses may be suffered on individual crops even when the general supply of pickers is adequate.

A study of the whole picking problem is therefore an important part of the analysis of the marketing situation in any section, and any suggestions based upon successful experience in dealing with pickers should be of value.

The market quality of the berries depends very largely upon the knowledge and integrity of the pickers, who are, in most cases, paid for the quantity of berries which they deliver to the packing shed.

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[1] See Sherman, W. A., Walker, H. F., and Schleussner, O. W. **Strawberry Supply and Distribution in 1914.** U. S. Department of Agriculture Bulletin 237.

Under these conditions there is often a tendency on the part of the pickers to do unsatisfactory work.

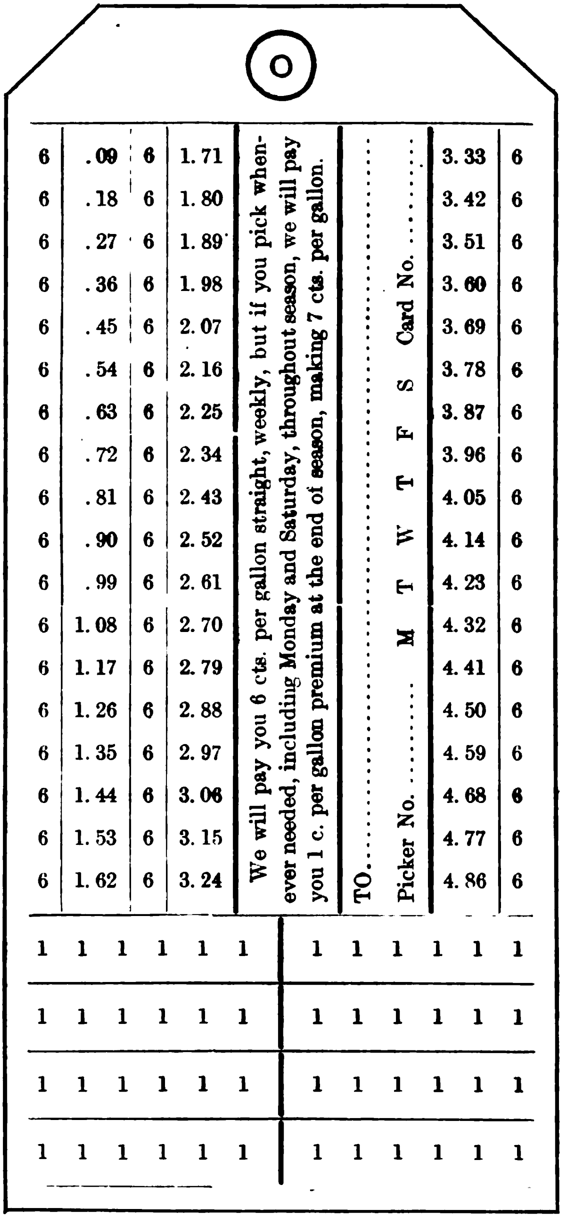
Various methods of handling pickers were observed during the 1915 season, the most satisfactory of which included a "field boss," who assigned each picker certain rows, and who continually supervised them to see that they harvested only berries of the proper degree of maturity, and that care was exercised in handling both the berries and the vines. The grower was also represented at the packing shed by a "ticket giver," who passed upon the acceptability of the berries delivered, and who credited the picker for work done. The field inspection when efficient usually reduced the work at the receiving shed to a mere recording of the amounts delivered by each picker.

Different growers have worked out various schemes for keeping their accounts with pickers. In some localities it is the practice to give them small printed tickets indicating the number of quart or pint boxes delivered. These are afterwards exchanged for tickets representing a case each, which are redeemed in cash once a week. In one district growers use small metallic checks furnished by storekeepers, who accept these checks in trade at any time, if so desired. These checks were also redeemable by the grower in cash each week.

In one section the use of a punch ticket appears to combine the best qualities of the small tickets and checks, with the added advantage of establishing the ownership of the ticket in case it should be lost. This ticket is reproduced in figure 1. A promise to pay a bonus to the picker if he is always available for work during the entire season is printed on its face and tends to insure the grower a regular supply of help upon which he can depend. It is probable that a dependable supply of workers would be made more certain if the grower were to guarantee the picker a minimum number of working days within the limits of the normal harvesting season.

## COOPERATIVE ASSOCIATIONS.

With the increasing necessity for more elaborate methods of disposal of the crop than those practiced by the small individual growers many cooperative marketing associations have come into existence. Practically every important producing section has one or more of these associations. In some areas—the Louisiana district and the southwest Missouri district, for instance—a number of different organizations have developed because of a divergence of interests, or on racial lines.



| | | | | | |
|---|---|---|---|---|---|
| 6 | .09 | 6 | 1.71 | 3.33 | 6 |
| 6 | .18 | 6 | 1.80 | 3.42 | 6 |
| 6 | .27 | 6 | 1.89 | 3.51 | 6 |
| 6 | .36 | 6 | 1.98 | 3.60 | 6 |
| 6 | .45 | 6 | 2.07 | 3.69 | 6 |
| 6 | .54 | 6 | 2.16 | 3.78 | 6 |
| 6 | .63 | 6 | 2.25 | 3.87 | 6 |
| 6 | .72 | 6 | 2.34 | 3.96 | 6 |
| 6 | .81 | 6 | 2.43 | 4.05 | 6 |
| 6 | .90 | 6 | 2.52 | 4.14 | 6 |
| 6 | .99 | 6 | 2.61 | 4.23 | 6 |
| 6 | 1.08 | 6 | 2.70 | 4.32 | 6 |
| 6 | 1.17 | 6 | 2.79 | 4.41 | 6 |
| 6 | 1.26 | 6 | 2.88 | 4.50 | 6 |
| 6 | 1.35 | 6 | 2.97 | 4.59 | 6 |
| 6 | 1.44 | 6 | 3.06 | 4.68 | 6 |
| 6 | 1.53 | 6 | 3.15 | 4.77 | 6 |
| 6 | 1.62 | 6 | 3.24 | 4.86 | 6 |

We will pay you 6 cts. per gallon straight, weekly, but if you pick whenever needed, including Monday and Saturday, throughout season, we will pay you 1 c. per gallon premium at the end of season, making 7 cts. per gallon.

TO..............................................

Picker No. ............ M T W T F S Card No. ............

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

FIG. 1.—Ticket used by strawberry pickers.

letails
en the
lies of
boxes.
g help
ve or-
intain
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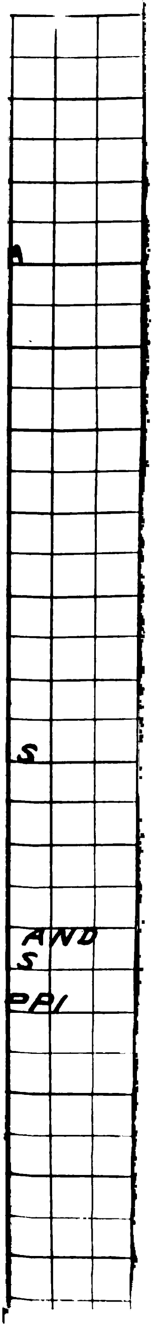

1915.

These organizations have relieved the grower of most of the details the disposal of his crop, and in many cases have undertaken the icult responsibility of securing a sufficient quantity of supplies of per quality, such as berry plants, fertilizers, crates, and boxes. ne associations even maintain a labor bureau for securing help ing the harvesting season. The success of such a cooperative orization depends upon the united efforts of all members to maintain igh degree of efficiency and so to frame the requirements of the anization that those composing it will feel the responsibility of ir membership.

n some cases, by concerted action, a number of local organizas have secured a high degree of uniformity in the grade and pack he berries.

ll associations do not perform the same functions for their mems, as some of them take the entire responsibility for the disposal of crop, and others only load cars which are consigned to various ns in the markets as designated by the growers. Some associans practically pay cash for berries delivered, and others do not. ious methods of handling the business of the association have been ked out to meet the requirements of the different types of busis carried on.[1] Different associations have developed different es of receipts to be given the growers for berries delivered. A few hese typical forms are shown on pages 6 and 7.

igure 2 is the type of receipt used by an association which sold s on track at the loading point to representatives of northern olesale houses. Under these conditions the prices for the different des and varieties are usually established by noon each day, and as berries are not delivered at the cars until afternoon or evening, price can be indicated on the receipt when it is issued to the ower.

Figure 3 is the form used in a locality where the association does not dertake the sale of the berries. In 1915 this association purchased pplies for its members, arranged with the railroad for an adequate pply of iced cars, and kept a record of the berries shipped and of the mes of the firms receiving them. The actual disposal of the berries s arranged for by the grower, who dealt directly with the represenives of the wholesale houses in the single market to which all berries m this section go. The grower made out his receipt in duplicate, ing one copy to the bookkeeper, who made out the car manifests. ese were used as delivery sheets by the agent in the market, who ivered the different lots of berries to the various consignees as quested by the growers. Such an arrangement as this is possible ly where all berries are sold on consignment.

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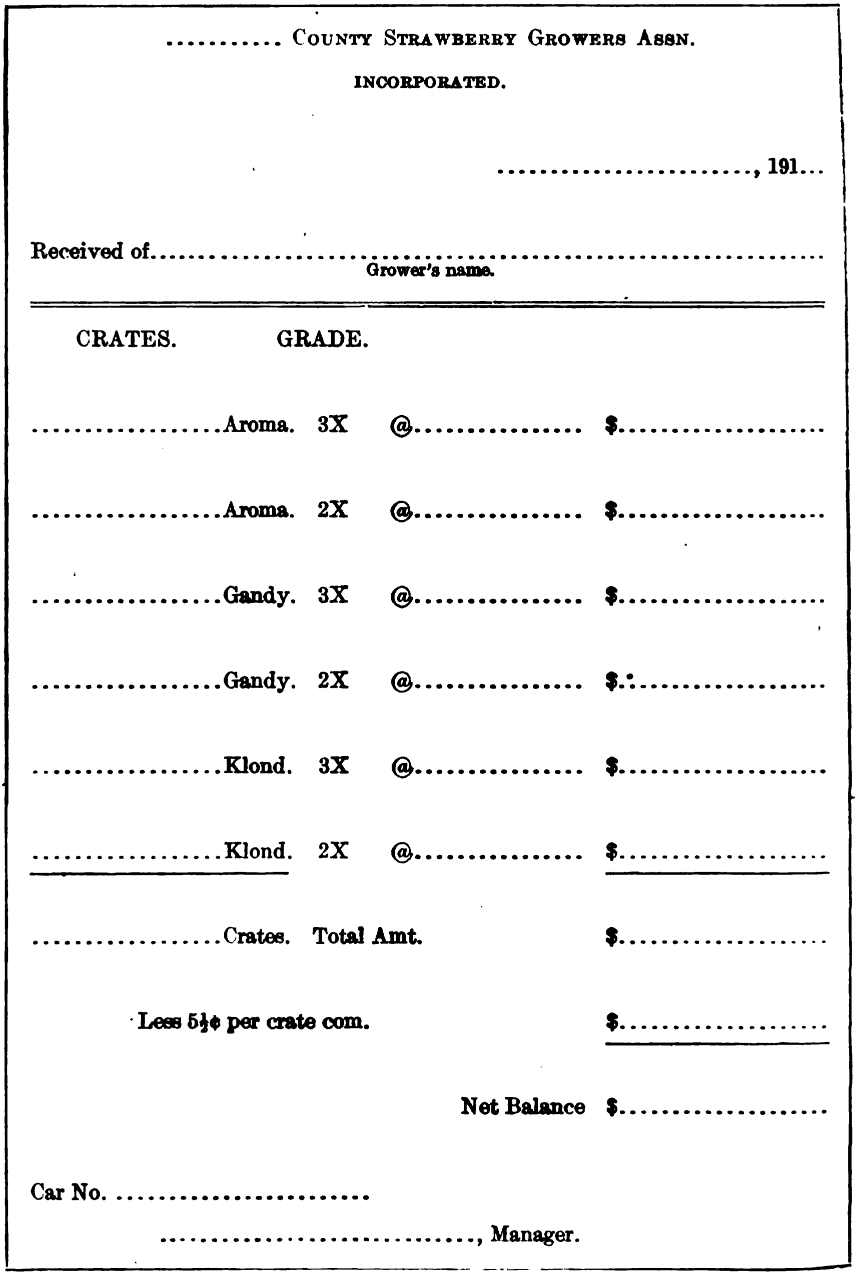
[1] ee Nahstoll, G. A., and Kerr, W. H. A System of Accounting for Cooperative Fruit Associations. . Dept. of Agriculture Bul. 225, 1915.



........... COUNTY STRAWBERRY GROWERS ASSN.

INCORPORATED.

......................., 191...

Received of..........................................................................
Grower's name.

| | | | | |
|---|---|---|---|---|
| CRATES. | GRADE. | | | |
| .................. | Aroma. | 3X | @................ | $..................... |
| .................. | Aroma. | 2X | @................ | $..................... |
| .................. | Gandy. | 3X | @................ | $..................... |
| .................. | Gandy. | 2X | @................ | $..................... |
| .................. | Klond. | 3X | @................ | $..................... |
| .................. | Klond. | 2X | @................ | $..................... |
| .................. | Crates. | Total Amt. | | $..................... |
| | Less 5½¢ per crate com. | | | $..................... |
| | | | Net Balance | $..................... |

Car No. ........................

................................., Manager.

FIG. 2.—Receipt used by cooperative association for strawberries delivered by growers.

........................., 19...

From.............................................................................
Grower's name.

| Consignees. | No. packages. | Size. | Kinds. |
|---|---|---|---|
| To.................................. | .............. | ....... | ................ |
| ..................................... | .............. | ....... | ................ |
| ..................................... | .............. | ....... | ................ |
| ..................................... | .............. | ....... | ................ |
| ..................................... | .............. | ....... | ................ |
| ..................................... | .............. | ....... | ................ |

Car No. ..........

FIG. 3.—Receipt used by cooperative association for strawberries delivered by growers.

---

Grower's Shipping No. ................

Date............................, 191...

RECEIPT No. 4451.

Cases 24 Boxes Strawberries graded A No. ........................

" " " " B No. ........................

Loaded in Car No. .................. Initial of Car..........................

No. of Cases rejected...................

No. Cases transferred to car...... No. Cases transferred from car..............

.................................., Inspector.

FIG. 4.—Receipt used by cooperative association for strawberries delivered by growers.

Figure 4 is typical of the forms used by associations which assume responsibility for assembling and disposing of the berries. This particular form provides for the contingency of transfers of cases from one car to another in order to fill orders for certain varieties. This receipt also has the desirable feature of attaching responsibility for inspection to a particular inspector. Such features are found helpful in securing better grading and packing.

The expenses of the association which the grower necessarily must bear consist of a few well-defined items, namely: First, salaries for the manager, sales manager or other officers, the inspectors, and any other necessary help; second, rental of or taxes on loading sheds, and depreciation of property, such as loading sheds, offices, etc.; third, stationery, postage, telegrams, and other miscellaneous items. The necessary money is secured either by charging the grower a fixed sum per crate of berries or a certain percentage of the gross returns.

## SALES METHODS COMMONLY EMPLOYED.

Under all present systems of doing business it appears necessary that the large operators station their representatives in the producing areas in order to deal with the association manager or the individual grower, as the case may be. Apparently both buyers and growers find it most satisfactory, under present conditions, to do business by this method. However, with established grades and standards for berries and an impartial inspection service conducted by some disinterested party, it is possible that buyers' and solicitors' salaries and traveling expenses might be saved. In some instances the representatives of the wholesale houses act entirely as cash buyers, while in other instances they solicit consignments and endeavor to secure the quality and variety of berries desired by their firms.

## TRANSPORTATION.

So vital is the service of the railroad and refrigerator-car companies to the soft-fruit business that any discussion of marketing strawberries would be incomplete without mention of railroad method and equipment. At various points during the 1915 season it was observed that each road dealt with the shippers according to the demands of the local situation rather than according to any fixed program.

All service which a railroad may offer must of necessity be based on published tariffs, and whether the railroad assumes all or little responsibility, there must be a tariff provision which covers the items. The railroad agent deals with the shippers, either as individuals or associations, and they must negotiate through him for service in distributing the berry crop. In the localities where the volume of shipments is large, the railroads usually have provided adequate facilities for the handling of berries.

In one instance it was noted that where there was competition for the tonnage the roads provided splendid facilities for handling the berries, icing the cars, and insuring rapid movement to destinations. At another point served exclusively by one of the same roads no facilities were provided, except the right to load cars on the team tracks near the station. At the particular competitive station referred to the railroads even took over the loading and bracing of the cars, and assumed responsibility for the condition of the load on arrival. At several noncompetitive stations visited, however, the shipper did all the loading, stripping, and bracing in the cars and paid all costs connected with these operations. At most shipping stations where observations were made the railroads or the refrigerator-car lines did the initial icing of the cars and made arrangements for all necessary icings in transit.

## A STUDY OF THE LOUISIANA DISTRICT.

One of the authors was stationed in the Louisiana strawberry district during the active shipping season of 1915 to distribute telegraphic market news and to study distribution problems there. The office did not have an opportunity to make studies in similar detail elsewhere during that season.

### HISTORY.

The Louisiana district is one of the most important commercial strawberry-growing districts in the United States. Probably no area of equal size produces a larger quantity of berries. The entire district is confined to the parish of Tangipahoa, the production area being located on both sides of the line of the Illinois Central Railroad from Ponchatoula to Amite City, a distance of 20 miles.

The industry is very important locally, many of the farmers being almost entirely dependent upon the strawberry crop for their cash income. Its importance is illustrated by the fact that in one town the school year is so arranged that the vacation comes at the time of the strawberry harvest, leaving the children free for berry picking.

The time of shipment of the Louisiana crop also makes it of peculiar interest to the dealer and consumer, as it is the first region shipping strawberries largely in carloads, the season normally beginning about April 1.

The industry has been in existence for many years, but only since 1910 has it grown to considerable proportions. During the early years Chicago was the sole market, and this city still takes a heavy supply. However, in the 1915 season more than 60 markets, scattered from Boston to Seattle, were reached, thus giving the crop a wider distribution than that from any other section, and making it a matter of national interest.

### MARKETING ARRANGEMENTS.

The strawberry growers in Louisiana are well organized, practically all being members of local shipping associations. In fact, there are frequently two, three, or even four such associations at one station. There seems to be a rather unnecessary duplication of selling expense by reason of the operation of several associations at shipping points where the business is so limited that all of it could easily be handled by one association at a smaller cost.

The northern houses usually send a large number of buyers to the district during the car-lot movement, and sales are made on a cash f. o. b. shipping-point basis, inspection being made and acceptance being taken before the cars move. In general, this method has proved satisfactory. At Ponchatoula practically all cars are sold at public auction. As this point has the reputation of producing superior berries, the auction has worked satisfactorily. It is unique in that it is the only point in the United States, so far as is known, where full carloads of strawberries are sold at auction.

The association charge for selling berries usually is 5 cents per crate, a refund generally being made to the growers after expenses are paid. A considerable portion of the crop is handled by a distributing company for the account of local associations, a fixed charge being made for this service.

A very essential feature of the work of the local associations is the financing of the growers by supplying them with fertilizers, feed, crate material, etc. The purchase of supplies through the local associations is especially important in Louisiana, and this form of association activity is growing.

### QUALITY AND PACK.

In general, Louisiana berries enjoy a fairly good reputation for quality and pack. Varieties are fairly well standardized, and when weather conditions have been favorable, deterioration in marketing has not been excessive. In certain seasons, when the weather has been unfavorable, the losses from deterioration have been heavy.

Berries usually are carried from the field to the packing shed in picking trays, and are there packed in boxes. While the packing probably is as good as in most shipping sections, there is urgent need for improvement. A number of cars noted by the market reporters of the office showed very slack pack. One car in Pittsburgh was examined and the cups were found to be barely half full. Several dealers were arrested in that city for selling these short-measure cups of berries.

Two types of crates are in use, the unventilated (Hallock) with solid sides, and the ventilated (Dahlstrom) with slatted sides. Careful examination on the Chicago market showed that the berries packed in the ventilated crates consistently arrived in better condition, although in a few exceptional cases the reverse was true. Labels were used in 1915 for the first time. Wholesalers interviewed expressed themselves as pleased with the labeling of the crates and believed it added to the selling value.

### SHIPPING.

Most of the Louisiana crop is shipped in express cars. These shipments generally have carried better than freight shipments, have given better satisfaction, and consequently have sold at consistently better prices.

The distribution of freight and express cars from the Louisiana district in 1915 to all markets is shown in Table 1.

TABLE 1.—*Destination points of berry cars shipped from the Louisiana district, season 1915.*

| Destination. | Freight cars. | Express cars. | Destination. | Freight cars. | Express cars. |
|---|---|---|---|---|---|
| Aberdeen, S. Dak |  | 1 | *Minneapolis, Minn | 5 | 37 |
| Bloomington, Ill | 2 |  | *Montreal, Canada |  | 25 |
| *Boston, Mass |  | 46 | Marshfield, Wis | 2 |  |
| Bridgeport, Conn |  | 1 | Mounds, Ill | 14 |  |
| *Buffalo, N. Y | 4 | 40 | Muskogee, Okla | 1 |  |
| Burlington, Iowa | 3 |  | New York, N. Y |  | 10 |
| Calgary, Alberta |  | 7 | Oklahoma City, Okla | 1 | 7 |
| Cedar Rapids, Iowa | 1 | 1 | *Omaha, Nebr |  | 41 |
| Champaign, Ill | 1 | 1 | Ottawa, Ontario |  | 1 |
| *Chicago, Ill | 355 | 292 | Ottumwa, Iowa |  | 1 |
| Cincinnati, Ohio |  | 1 | Peoria, Ill |  | 10 |
| Cleveland, Ohio | 1 | 5 | Philadelphia, Pa |  | 3 |
| Council Bluffs, Iowa |  | 1 | *Pittsburgh, Pa | 16 | 26 |
| Davenport, Iowa | 6 | 2 | Providence, R. I |  | 7 |
| *Denver, Colo |  | 18 | Pueblo, Colo |  | 1 |
| *Des Moines, Iowa | 12 | 18 | Regina, Saskatchewan |  | 2 |
| *Detroit, Mich | 3 | 21 | Rockford, Ill | 2 |  |
| Duluth, Minn | 2 |  | St. Joseph, Mo |  | 2 |
| East St. Louis, Ill | 1 |  | *St. Louis, Mo | 34 | 23 |
| Elgin, Ill | 1 |  | *St. Paul, Minn | 6 | 22 |
| Erie, Pa |  | 2 | Seattle, Wash |  | 2 |
| Fargo, N. Dak |  | 2 | Sioux City, Iowa | 1 | 12 |
| Fort Wayne, Ind | 2 | 1 | Sioux Falls, S. Dak |  | 7 |
| Freemont, Nebr |  | 1 | South Bend, Ind |  | 1 |
| Freeport, Ill | 4 |  | Springfield, Ohio | 1 |  |
| Grand Island, Nebr |  | 3 | Toledo, Ohio |  | 5 |
| Grand Rapids, Mich | 6 | 5 | Topeka, Kans |  | 5 |
| Hastings, Nebr |  | 1 | Toronto, Ontario | 3 |  |
| *Indianapolis, Ind | 11 | 19 | Tulsa, Okla |  | 4 |
| Jamestown, N. Y |  | 1 | Waterloo, Iowa |  | 1 |
| *Kansas City, Mo | 1 | 26 | Winnipeg, Manitoba | 1 | 12 |
| Lafayette, Ind | 4 |  | Worcester, Mass |  | 3 |
| Lincoln, Nebr |  | 15 | Carbondale, Ill | 11 |  |
| Louisville, Ky | 4 | 2 |  |  |  |
| *Milwaukee, Wis | 14 | 10 | Total | 536 | 854 |

* Cities used over 15 cars during the season.

## EXTENT, LENGTH, AND VOLUME OF MOVEMENT FROM ALL DISTRICTS.

The extent, length, and volume of the commercial strawberry movement of the various important districts of the United States, as reported by telegraph to the Office of Markets and Rural Organization, are illustrated in figure 5. This chart is incomplete, since omissions were noted frequently in the reports received from the railroads daily by telegraph. Of total shipments throughout the United States, amounting to 13,409 cars, the railroads reported by telegram the movement and destination of 11,059½ cars, or 82.5 per cent of the total as furnished from their records at the end of the season. The reason for the incompleteness of these reports may be traced to the fact that no attempt was made to report on l. c. l.[1] movement by telegram. When the sources of information are scattered and reports are voluntary and without compensation, a certain number of errors and omissions must be expected. Physical conditions made it impossible to secure records of some cars, railroad records in some cases being in such shape that it was impossible to get the required information. However, on the whole, railroad officials cooperated so heartily and effectively that it can be said that the reports present the best picture of the proportionate movement from different sections, the extent and length of that movement, and the volume on any one day, that has yet been presented.

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[1] l. c. l. is the usual abbreviation for less than carload lots.

The reports begin with the opening of the carload season in Louisiana. Although Florida had been shipping berries in "pony" refrigerators[1] for some time prior to this, and shipped some carloads a short time after the Louisiana movement was started, at the time the work was inaugurated early in April it was impossible to secure complete reports of Florida shipments.

The largest shipment made in any one day from any one section was 182 cars from the Norfolk section, May 18. The same section shipped 163 cars May 22, 159 cars on May 24, and 142 cars May 19. The Carolinas made the next largest shipment, 140 cars on May 11, while Norfolk had 139 cars May 27, 137 cars May 25, and Tennessee 136 cars May 12 and 134 cars on May 13. These three sections, which are among the heaviest shipping sections in the United States, were at their height at practically the same time.

The Delaware-Maryland district, which is also a heavy shipper, was very fortunate in 1915 in that it escaped practically all of this very severe competition, heavy shipments from this district not beginning until May 25 and continuing until June 19. Early local berries, regarding which no figures are available, are probably heavy competitors of Delaware and Maryland stock in the northern markets, as are also Jerseys. The chart of shipments would seem to show that, of the northerly districts, the Delaware-Maryland section was peculiarly favored with desirable market conditions. These conditions were reflected in the satisfactory prices paid on the markets for Delaware and Maryland stock during the season.

The period of heaviest shipments for the whole country was from May 10, when 311 cars were shipped, to May 26, when 296 cars moved. During this period there were only four days when less than 275 cars were moved, while this number was never reached at any other time during the whole season. On May 23, the heaviest shipping day of the season, 401 cars were moved, and on May 25, 400 were shipped. The third largest day was May 11, with 384 cars. While every shipping season will not coincide exactly with that of 1915 (that season being a trifle late in the southern districts), a heavy berry movement between approximately the same dates can be expected each year.

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[1] "Pony" refrigerators are small refrigerators usually holding 64 or 80 quarts, and usually shipped by express.

## COMPARISONS OF PRICES RECEIVED FOR STRAWBERRIES ON IMPORTANT MARKETS.

Figures 6 to 11 show comparisons of the jobbing prices for berries from various sections, on the New York, Pittsburgh, Buffalo, Chicago, St. Louis, and St. Paul markets from day to day. These were prepared from the telegraphic reports received from the markets during the season. The low and high prices are represented for each day, the range between the two being blacked in. Where only one price was quoted, the price variation from day to day is shown by a single line. On days when there were no berries from a certain section on the market and no quotations, this fact is shown by a dotted line. The prices quoted in New York are per quart, and those quoted in other markets are per 24-quart crate, as this type of crate is the one most commonly used in these markets. Quotations covering berries from sections using styles of crates other than 24-quart (such as the 32-quart from Delaware and Maryland) have been reduced to a basis of 24-quart crates for purposes of comparison. The black horizontal line running from left to right indicates a price of 10 cents per quart, or $2.40 per 24-quart crate, this being selected as a median line.

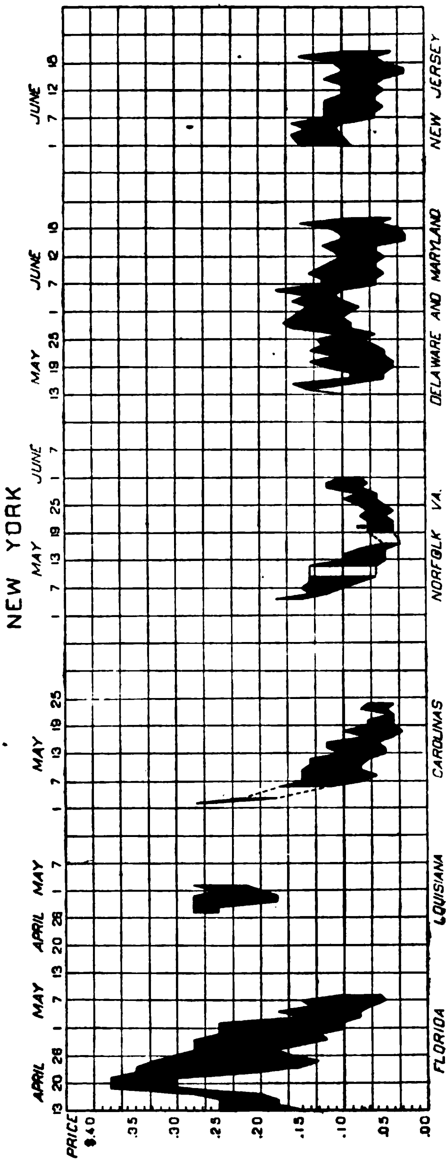

FIG. 6.—Jobbing prices of strawberries on the New York market in 1915.

### DIFFERENCES IN PRICES CAUSED BY RANGE IN QUALITY.

The width of the black space on any one day represents the range in quality between the best and poorest berries appearing on the market on that day from the section indicated. The need for standardization of growing and packing methods is illustrated only too well by the wide ranges in price throughout the season.

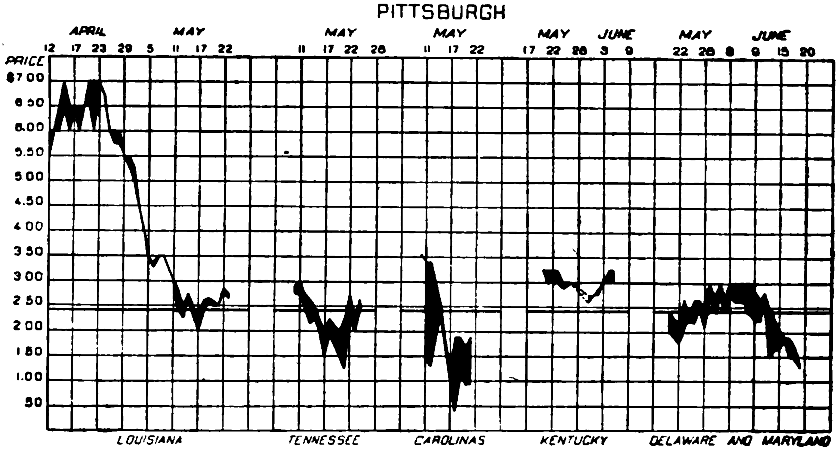

FIG. 7.—Jobbing prices of strawberries on the Pittsburgh market in 1915.

Of the various sections represented, Florida appears to have the widest range in quality, on May 23 showing a range of 20 cents per quart (from 15 to 35 cents) in New York. This may be partially due to the fact that when prices are high the price ranges are naturally more marked. On the other hand, Louisiana berries sold at high

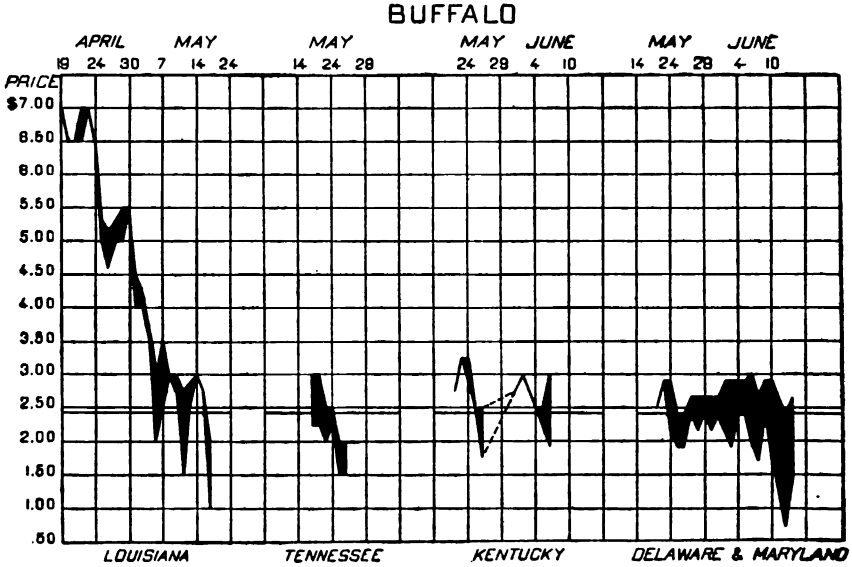

FIG. 8.—Jobbing prices of strawberries on the Buffalo market in 1915.

prices for most of the season in all markets, yet the price range was comparatively much narrower, the greatest variation between good and poor being 10 cents per quart (from 18 to 28 cents) in New York on May 29. In other markets during most of the season the range on Louisiana berries was seldom over 5 cents per quart, and usually was much less than this. The wide range in prices is generally more marked on eastern markets than on western. This may be traced in part to the well-known fact that western produce which supplies western markets generally is more carefully graded and packed than eastern, because associations are stronger in the West and also because high freight rates make the marketing of inferior grades unprofitable.

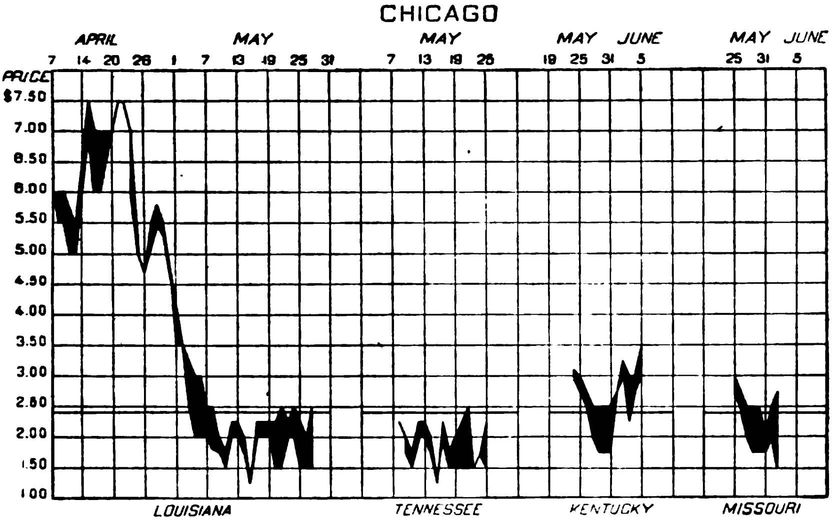

FIG. 9.—Jobbing prices of strawberries on the Chicago market in 1915.

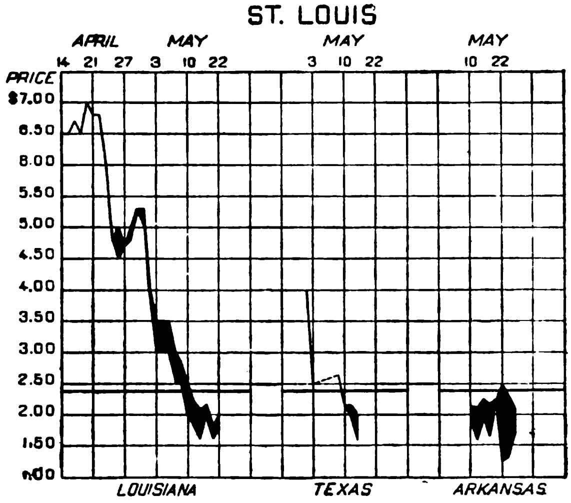

FIG. 10.—Jobbing prices of strawberries on the St. Louis market in 1915.

In general it can be said that the range in prices indicates a range in quality and leads to the conclusion that methods of grading and packing could be much improved in all sections. Especially is this true of sections that regularly show wide differences between their good and poor qualities. They can profit by adopting the methods of sections producing berries of excellent reputation, such as Kentucky, which never showed a price range greater than 25 cents per 24-quart crate on the Pittsburgh market throughout the entire season. Often there are individual growers who uniformly secure top prices for their goods, while others always receive the lowest prices. The difference between top prices and bottom prices is often a difference between profit and loss, or success and failure. This emphasizes the fact that berries of high quality usually pay for the extra cost of their production.

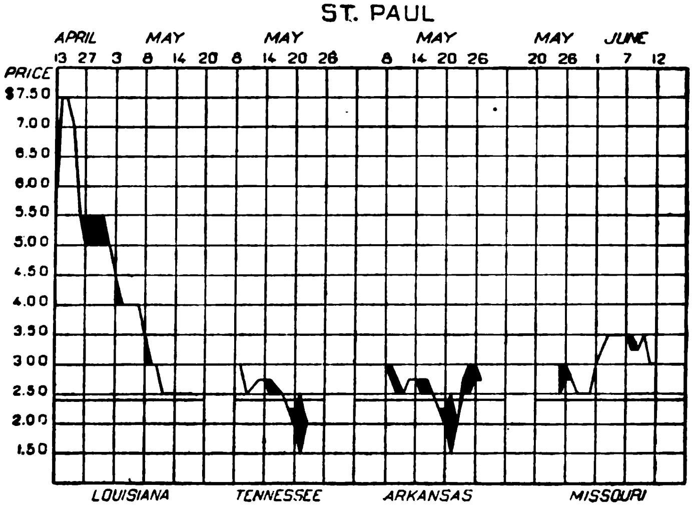

FIG. 11.—Jobbing prices of strawberries on the St. Paul market in 1915.

It should not be inferred, however, that the price range depends entirely on quality. Other elements enter in, especially the element of salesmanship. One salesman may habitually secure less than another. Nevertheless the greatest single factor in price range in one day is quality.

### DIFFERENCES IN PRICES CAUSED BY TIME OF SHIPPING.

The curves showing the prices of berries from the different sections show that first shipments from any section usually top the market. As shipments increase, the market usually declines. Later there may be a reaction and an advance. A notable exception to this rule in 1915 was Louisiana, which showed an advancing and strengthening market in practically every city for 10 days after the season opened. This may be attributed to two reasons—light shipments and demand stimulated by satisfactory quality[1]. The same causes operated to cause a consistent advance in Pittsburgh and some other markets for two weeks after first receipts from Delaware and Maryland. These conditions, however, are unusual. In general, as the season in each district advances, the price is influenced by deteriorating quality[1] due to continued picking and by increased supplies.

## AVERAGE QUALITY OF STRAWBERRIES SHIPPED.

In 1915 certain sections suffered from unfavorable weather such as drought during the growing season and rain at harvest time. Certain of these sections suffered the results of unsatisfactory quality by receiving uniformly unsatisfactory prices. Tennessee was unfortunate in this respect. In addition, the great bulk of her crop came on the market at the time of heaviest shipments from May 10 to 25. Norfolk and the Carolinas suffered in the same way. However, a comparison of these two sections with others on the market at the same time shows their quality must have been unsatisfactory, as they sold on almost every day at lower prices than the others.

In New York, average berries from the Norfolk section never sold above 10 cents from May 9 to May 24. From May 9 until May 18, the date of last receipts in New York, Carolina berries sold above 10 cents on only two days. Beginning on May 9, and up to June 15, Delaware and Maryland berries brought less than 10 cents for best stock on only two days. On any given day they brought a considerably better price than Norfolks and Carolinas, and continued at a fairly satisfactory level the entire season.

In Pittsburgh, the Carolinas and Tennessees sold at low prices compared to Kentucky and Delaware-Maryland stock. The Kentucky stock did especially well, the poorest never selling as low as 10 cents per quart. Kentucky berries generally have an enviable reputation based on good pack.

The comparative inferiority of Tennessee berries was also shown in Buffalo where prices were lower than for Kentucky and Delaware-Maryland berries selling at the same time. In Chicago the Tennessee berries sold as high as $2.40 a crate (10 cents a quart) on only one day, and even then most of them were sold at a lower price. However, there are no quotations available for a satisfactory comparison with other berries in the Chicago market at the same time, the chief competition being from Louisiana berries, which were quite poor, as they were the last shipments at the end of a long season. A few Tennessee berries were also quoted on the St. Paul market and sold at practically the same prices as the Arkansas stock offered.

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[1] The term "quality" is used in the commercial sense indicating satisfactory grade upon arrival at market and delivery to the consumer.

In general, the market quality of Louisiana, Kentucky, Missouri, Arkansas, and Delaware-Maryland berries seems to have been fairly satisfactory in 1915, while the Tennessee, Norfolk, and Carolina stock was not quite so well received. From this it must not be inferred that identical conditions will prevail in the future, as they may be quite reversed. The foregoing refers to the 1915 season only.

## DISTRIBUTION OF STRAWBERRIES IN 1915.

Shipments of straight carloads of strawberries to 299 different towns and cities in the United States during the season of 1915, according to telegraphic reports furnished to the Office of Markets and Rural Organization by the railroads during that season have been tabulated by districts and destinations in Table 2. This tabulation includes reports of all diversions, so far as it was possible to secure them. Fairly comprehensive arrangements were made with railroads at the beginning of the season, so that it is believed reports of diversions are practically complete, but this table is given as an approximate rather than an absolutely correct report.

According to these reports the center of heaviest strawberry consumption in 1915 was what may be called the metropolitan district, including New York, Melrose (upper New York City), Jersey City, Newark, and Paterson. This district may be considered practically a unit, as the supplies received in Jersey City are sold largely in New York, though to some extent in New Jersey, while Newark and near-by cities often purchase heavily on the New York market. The metropolitan district absorbed, in all, 1,964 cars. The next heaviest consumer was Chicago, with 884 cars; third, Boston, with 781 cars; fourth, Cincinnati, with 396 cars; fifth, Pittsburgh, with 359 cars; and sixth, Philadelphia, with 300 cars. Other cities receiving 100 cars or more were Buffalo, N. Y., Cleveland, and Columbus, Ohio, Detroit, Mich., Kansas City, Mo., Minneapolis, Minn., Omaha, Nebr., Rochester, N. Y., St. Louis, Mo., and St. Paul, Minn. The relatively small number of cars of strawberries shipped to Philadelphia may be accounted for in part by the heavy receipts of l. c. l. shipments from near-by districts. The figures for Boston and New York include boat shipments from the Norfolk district reduced to equivalent carloads.

Many small towns and cities with populations of but a few thousand received supplies of from 1 to 10 cars during the season. While these small markets are not heavy consuming factors individually, in the aggregate they take heavy supplies and are of great importance to shippers. It is altogether probable that many similar small markets which do not now receive full carloads could be developed to the advantage of both the strawberry grower and the consumer.

Figures 12A to 12C (facing p. 24) are maps representing graphically the distribution of strawberries as reported by wire in 1915 for all districts shipping more than 175 cars. It will be seen that in most cases each producing section shipped very heavily to a certain limited consuming area, and in some cases entirely confined its shipments to that area

The widest distribution was reached in Louisiana (see fig. 12A), as from this district both Atlantic and Pacific coast markets were reached. This unusually wide distribution was due largely to lack of competition, as other districts do not produce so early, and also to geographical position, Louisiana being practically midway between the two. However, even this district depends largely upon a single market, as Chicago took 647 cars out of a total of 1,335.

Alabama shipped principally to Ohio and Michigan points, Cincinnati and Detroit taking 163 and 58 cars, respectively, out of a total of 314 cars. (See fig. 12B.)

The Carolinas, Virginia, and New Jersey districts depended almost entirely upon the Atlantic seaboard markets, especially Philadelphia, the metropolitan district, and Boston. (See fig. 12B.) These districts shipped very lightly to points no farther west than Pittsburgh and Buffalo, and depended very generally upon the large markets. New Jersey, for instance, shipped 800 cars to Jersey City and 100 to New York, out of a total of 1,291 cars.

In contrast, the Delaware-Maryland district (fig. 12B) distributed heavily to smaller towns, and also to towns in the interior of the States of Pennsylvania, New York, Ohio, and Michigan, and even as far west as Chicago. A much smaller percentage of the total movement went to the large seaboard markets, while towns such as Elmira, N. Y., Erie, Pa., Bridgeport, Conn., Altoona, Pa., Worcester, Mass., and Wilkes-Barre, Pa., were supplied. Many others received fairly liberal shipments. It is a question whether this efficient distribution was not a considerable factor in the successful marketing of the berries from this district in 1915.

West Tennessee (fig. 12B), with 506 cars, probably secured as wide distribution as any area with a similar quantity of shipments, reaching as far as Jacksonville, Fla., and Macon, Ga., to the southeast, Bangor and Portland, Me., to the northeast, and Winnipeg, Manitoba, Sioux Falls, S. Dak., and Lincoln, Nebr., to the northwest. Ohio points received the heaviest shipments going to any one State.

The distribution from East Tennessee (fig. 12B), with a total of 693 cars, was comparatively more restricted, a much larger percentage of the crop going to Ohio points. Cincinnati alone took 203 cars, while Dayton, Columbus, Cleveland, and Toledo each received 30 cars or more. From 1 to 20 cars were sent to numerous other Ohio points. Illinois and some western points received small shipments, while one car went to Regina, Saskatchewan.

Of the western strawberry sections, the Ozark district (fig. 1 secured fairly widespread distribution, sending cars as far east New York and Ottawa, Ontario, and as far west as El Paso, an considerable quantity (43 cars) to Denver. The chart shows, h ever, that Missouri River and near-by points (such as Omaha, Si City, St. Joseph, Topeka, Kansas City) and northwestern po (such as Minneapolis and St. Paul) form the principal outlets for district.

The Judsonia, Ark., district (fig. 12c) shipped more heavily Mississippi River points and cities nearby, and only lightly to souri River markets. St. Louis absorbed 151 cars of a total 297. This district also made scattering shipments to eastern Canadian points. Springfield, Ill., with 8 cars, received the heavi shipments of any city east of the Mississippi River.

Washington and Oregon sections (fig. 12c) shipped princip to Canadian and northwestern prairie States. A few scattered were shipped as far east as Chciago and Detroit, but these east shipments amounted to but a small proportion of the total moveme

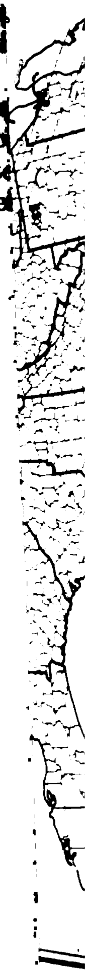

TABLE 2.

| Destination. | Louisiana. | Alabama. | Carolinas. | Arkansas. | Ozarks. | Virginia. | West Tennessee. | East Tennessee. | Texas. | Washington and Oregon. | Kentucky. | Delaware and Maryland. | Iowa. | New Jersey. | Michigan. | Indiana. | Connecticut. | New York. | Wisconsin. | Total receipts. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aberdeen, S. Dak | 1 | | | 1 | 6 | | | | | | | | 1 | | | | | | | 9 |
| Akron, Ohio | | 1 | | | | | 8 | 18 | | | 3 | 5 | | | | | | | | 35 |
| Albany, N. Y | | | 10 | | | 10 | 6 | 1 | | | | 56 | | 2 | | | | | | 85 |
| Albert Lea, Minn | | | | 2 | 1 | | | | | | | | | | | | | | | 3 |
| Allentown, Pa | | | 1 | | | | | | | | | 3 | | | | | | | | 4 |
| Alliance, Ohio | | | | | | | | 2 | | | 1 | 2 | | | | | | | | 5 |
| Altoona, Pa | | | 6 | | | | | | | | | 27 | | | | | | | | 33 |
| Amarillo, Tex | | | | | | | | | 3 | | | | | | | | | | | 3 |
| Amsterdam, N. Y | | | | | | | 1 | | | | | 10 | | | | | | | | 11 |
| Ashtabula, Ohio | | | | | | | | | | | | 3 | | | | | | | | 3 |
| Atchison, Kans | | | | | 2 | | | | | | | | | | | | | | | 2 |
| Atlanta, Ga | | 2 | | | | | | | | | | | | | | | | | | 2 |
| Auburn, N. Y | | | | | | | | | | | | 1 | | | | | | | | 1 |
| Baltimore, Md | | | 32 | | | | | | | | | | | | | | | | | 32 |
| Bangor, Me | | | | | | | 2 | | | | | 6 | | | | | 1 | | | 9 |
| Bellefontaine, Ohio | | | | | | | 2 | 6 | | | | | | | | | | | | 8 |
| Billings, Mont | | | | | | | | | | 4 | | | | | | | | | | 4 |
| Binghamton, N. Y | | | 1 | | | | | | | | | 19 | | | | | | | | 20 |
| Birmingham, Ala | | 10 | | | | | | | | | | | | | | | | | | 10 |
| Bismarck, N. Dak | | | | 1 | | | | | | 2 | | | | | | | | | | 3 |
| Bloomington, Ill | 2 | | | | | | | | | | | | | | | | | | | 2 |
| Boston, Mass | 46 | | 119 | 5 | 1 | 93 | 17 | | | | | 192 | | 149 | | | 159 | | | 781 |
| Bradford, Pa | | | | | | | | | | | | 5 | | | | | | | | 5 |
| Brandon, Manitoba | | | | | | | | | | 6 | | | | | | | | | | 6 |
| Brantford, Ontario | | | | | | | 1 | | | | | 4 | | | | | | | | 5 |
| Bridgeport, Conn | 1 | | 6 | | | 1 | 1 | | | | | 29 | | 3 | | | | | | 41 |
| Brockton, Mass | | | | | | | | | | | | 1 | | | | | | | | 1 |
| Buffalo, N. Y | 44 | 2 | 4 | 5 | 10 | | 29 | 17 | | | 12 | 120 | | 5 | | | | | | 248 |
| Burlington, Iowa | 3 | | | | 3 | | 2 | | | | | | 4 | | | | | | | 12 |
| Burlington, Vt | | | 1 | | | | 1 | | | | | 1 | | 1 | | | | | | 4 |
| Butte, Mont | | | | | | | | | | 16 | | | | | | | | | | 16 |
| Calgary, Alta | 7 | | | | | | | | | 1 | | | | | | | | | | 8 |
| Cambridge, Ohio | | | | | | | | 2 | | | | | | | | | | | | 2 |
| Canton, Ohio | | | | | | | | 8 | | | 3 | 3 | | | | | | | | 14 |
| Carbondale, Ill | 11 | | | | | | | | | | | | | | | | | | | 11 |
| Cedar Rapids, Iowa | 2 | | | | 5 | | 1 | | | | | | | | | | | | | 8 |
| Centerville, Iowa | | | | | | | | | | | | | 2 | | | | | | | 2 |
| Champaign, Ill | 2 | | | | | | | | | | | | | | | | | | | 2 |
| Chester, Pa | | | 7 | | | | | | | | | 2 | | | | | | | | 9 |
| Cheyenne. Wyo | | | | | | | | | | 1 | | | | | | | | | | 1 |

TABLE 2—Continued.

| Destination. | Louisiana. | Alabama. | Carolinas. | Arkansas. | Ozarks. | Virginia. | West Tennessee. | East Tennessee. | Texas. | Washington and Oregon. | Kentucky. | Delaware and Maryland. | Iowa. | New Jersey. | Michigan. | Indiana. | Connecticut. | New York. | Wisconsin. | Total receipts. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chicago, Ill | 647 | 1 |  |  | 76 |  | 75 | 10 |  | 11 | 36 | 26 |  |  | 2 |  |  |  |  | 884 |
| Cincinnati, Ohio | 1 | 163 |  |  |  |  | 29 | 203 |  |  |  |  |  |  |  |  |  |  |  | 396 |
| Clarksburg, W. Va |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  | 4 |
| Cleveland, Ohio | 6 | 22 |  |  |  |  | 9 | 67 |  |  | 12 | 30 |  |  |  |  |  |  |  | 146 |
| Coffeyville, Kans |  |  |  |  |  |  |  |  | 2 |  |  |  |  |  |  |  |  |  |  | 2 |
| Colorado Springs, Colo |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |
| Columbus, Ohio |  | 11 |  |  |  |  | 29 | 39 |  |  | 12 | 9 |  |  |  |  |  |  |  | 100 |
| Concordia, Kans |  |  |  | 2 | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |
| Conneaut, Ohio |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  | 1 |
| Corning, N. Y |  |  |  |  |  |  |  |  |  |  |  | 3 |  |  |  |  |  |  |  | 3 |
| Council Bluffs, Iowa | 1 |  |  |  | 1 |  | 1 |  |  |  |  |  | 1 |  |  |  |  |  |  | 4 |
| Crookston, Minn |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  | 4 |
| Dallas, Tex |  |  |  |  |  |  |  |  | 2 |  |  |  |  |  |  |  |  |  |  | 2 |
| Davenport, Iowa | 8 |  |  | 2 | 5 |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  | 17 |
| Dayton, Ohio |  | 5 |  |  |  |  | 3 | 31 |  |  | 1 |  |  |  |  |  |  |  |  | 40 |
| Deadwood, S. Dak |  |  |  |  | 2 |  |  |  |  | 3 |  |  |  |  |  |  |  |  |  | 5 |
| Delaware, Ohio |  |  |  |  |  |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  | 2 |
| Denver, Colo | 18 |  |  | 4 | 43 |  |  |  |  | 2 |  |  |  |  |  |  |  |  |  | 67 |
| Des Moines, Iowa | 30 |  |  | 3 | 27 |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  | 61 |
| Detroit, Mich | 24 | 58 | 1 |  | 18 |  | 20 | 32 |  | 3 | 23 | 48 |  |  | 1 |  |  |  |  | 228 |
| Devils Lake, N. Dak |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  | 1 |
| Dover, N. H |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| Du Bois, Pa |  |  | 1 |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  | 2 |
| Dubuque, Iowa |  |  |  |  |  |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  | 3 |
| Duluth, Minn | 2 |  |  | 4 | 5 |  | 5 |  |  | 7 |  |  |  |  |  |  |  |  | 9 | 32 |
| Edmonton, Alta |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  | 1 |
| Elmira, N. Y |  |  | 14 |  |  | 4 | 5 | 1 |  |  |  | 43 |  |  |  |  |  |  |  | 67 |
| Elgin, Ill | 1 |  |  |  |  |  | 1 | 2 |  |  |  |  |  |  |  |  |  |  |  | 4 |
| El Paso, Tex |  |  |  |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2 |
| Erie, Pa | 2 |  | 4 |  |  |  |  | 4 |  |  |  | 16 |  |  |  |  |  |  |  | 26 |
| Evansville, Ind |  | 2 |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  | 7 |
| Fargo, N. Dak | 2 |  |  |  |  |  |  |  |  | 7 |  |  |  |  |  |  |  |  |  | 9 |
| Findlay, Ohio |  |  |  |  |  |  | 1 | 4 |  |  |  |  |  |  |  |  |  |  |  | 5 |
| Fitchburg, Mass |  |  | 1 |  |  |  | 1 |  |  |  |  | 7 |  | 1 |  |  |  |  |  | 10 |
| Flint, Mich |  |  |  |  |  |  |  | 9 |  |  |  | 1 |  |  |  |  |  |  |  | 10 |
| Fonda, N. Y |  |  |  |  |  |  |  |  |  |  |  | 2 |  |  |  |  |  |  |  | 2 |
| Fort Dodge, Iowa |  |  |  | 1 | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |
| Fort Smith, Ark |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| Fort Wayne, Ind | 3 |  |  |  | 1 |  | 9 | 11 |  |  | 1 | 1 |  |  | 1 |  |  |  |  | 27 |
| Fort Worth, Tex |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  | 4 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Freeport, Ill | 4 | | | 1 | 1 | | | | | | | | | | | | | | | 6 |
| Fremont, Nebr | 1 | | | 1 | 1 | | | | | | | | | | | | | | | 3 |
| Galesburg, Ill | | | | | | | 10 | | | | | | 7 | | | | | | | 17 |
| Grafton, N. Dak | | | | | | | | | | 5 | | | | | | | | | | 5 |
| Glen Falls, N. Y | | | 3 | | | | | | | | | 15 | | | | | | | | 18 |
| Grand Forks, N. Dak | | | | | 2 | | | | | 8 | | | | | | | | | | 10 |
| Grand Island, Nebr | 3 | | | | 8 | | 3 | | | 1 | | | | | | | | | | 15 |
| Grand Rapids, Mich | 11 | 22 | | | 1 | | 6 | 4 | | | | 3 | | | 1 | | | | | 48 |
| Great Falls, Mont | | | | | | | | | | 3 | | | | | | | | | | 3 |
| Hamilton, Ohio | | | | | | | | 2 | | | | | | | | | | | | 2 |
| Hamilton, Ontario | | | 2 | 1 | | | | 1 | | | | 45 | | | | | | | | 49 |
| Hannibal, Mo | | | | 8 | 1 | | 3 | | | | | | 2 | | | | | | | 14 |
| Harrisburg, Pa | | | 2 | | | | | | | | | 5 | | | | | | | | 7 |
| Hartford, Conn | | | 9 | | | 1 | | | | | | 31 | | 5 | | | | | | 46 |
| Hastings, Nebr | 1 | | | 1 | 3 | | | | | | | | | | | | | | | 5 |
| Haverhill, Mass | | | | | | | 1 | | | | | | | | | | | | | 1 |
| Haselton, Pa | | | 1 | | | | | | | | | | | | | | | | | 1 |
| Helena, Mont | | | | | | | | | | 3 | | | | | | | | | | 3 |
| Hutchinson, Kans | | | | 1 | 9 | | | | 2 | | | | | | | | | | | 12 |
| Indianapolis, Ind | 30 | 2 | | | 2 | | 18 | 22 | | | 2 | | | | 1 | 10 | | | | 87 |
| Ithaca, N. Y | | | | | | | 1 | | | | | 9 | | | | | | | | 10 |
| Jacksonville, Fla | | | | | | | 2 | | | | | | | | | | | | | 2 |
| Jamestown, N. Y | 1 | | | | | | | | | | 2 | 1 | | | | | | | | 4 |
| Jersey City, N. J | | | 1 | | | | | | | | | 300 | | 800 | | | | | | 1,101 |
| Johnstown, Pa | | | 1 | | | | | | | | | 8 | | | | | | | | 9 |
| Joplin, Mo | | | | | 1 | | | | 2 | | | | | | | | | | | 3 |
| Kansas City, Mo | 27 | | | 8 | 146 | | | | 19 | 2 | | | | | | | | | | 202 |
| Keene, N. H | | | | | | | | | | | | 6 | | | | | 1 | | | 7 |
| Keokuk, Iowa | | | | 1 | | | 2 | | | | | | | | | | | | | 3 |
| Kokomo, Ind | | | | | | | | 2 | | | | | | | | | | | | 2 |
| La Crosse, Wis | | | | | | | 2 | | | | | | 4 | | | | | | | 6 |
| Lafayette, Ind | 4 | | | | 1 | | | | | | | | | | | | | | | 5 |
| Lansing, Kans | | | | | 1 | | | | | | | | | | | | | | | 1 |
| Lansing, Mich | | 2 | | | | | | | | | | | | | | | | | | 2 |
| Laramie, Wyo | | | | | | | | | | 1 | | | | | | | | | | 1 |
| Lawrence, Mass | | | | | | | | | | | | 2 | | | | | | | | 2 |
| Lewiston, Mont | | | | | | | | | | 2 | | | | | | | | | | 2 |
| Lexington, Ky | | 1 | | | | | | 1 | | | | | | | | | | | | 2 |
| Lima, Ohio | | 1 | | | | | | 16 | | | 1 | 4 | | | | | | | | 22 |
| Lincoln, Nebr | 15 | | | 1 | 13 | | 1 | 1 | | 3 | | | | | | | | | | 34 |
| Livingston, Mont | | | | | | | | | | 1 | | | | | | | | | | 1 |
| Lockport, N. Y | | | | | | | | | | | | 11 | | | | | | | | 11 |
| Logansport, Ind | | | | | | | 3 | 2 | | | 3 | | | | | | | | | 8 |
| London, Ont | | | 1 | | | | | | | | | 4 | | | | | | | | 5 |
| Louisville, Ky | 6 | 1 | | | | | 12 | 1 | | | 1 | | | | | | | | | 21 |
| Lowell, Mass | | | 2 | | | | 2 | | | | | 11 | | | | | | | | 15 |
| Macon, Ga | | | | | | | 2 | | | | | | | | | | | | | 2 |
| Mankato, Minn | | | | 2 | 3 | | 4 | | | | | | | | | | | | | 9 |
| Marion, Ohio | | | | | | | 2 | 7 | | | | 1 | | | | | | | | 10 |
| Mason City, Iowa | | | | 4 | 2 | | 2 | | | | | | | | | | | | | 8 |
| Marshfield, Wis | 2 | | | | | | | | | | | | | | | | | | | 2 |
| Manchester, N. H | | | | | | 4 | 5 | | | | | 7 | | | | | 1 | | | 17 |

TABLE 2—Continued.

| Destination. | Louisiana. | Alabama. | Carolinas. | Arkansas. | Ozarks. | Virginia. | West Tennessee. | East Tennessee. | Texas. | Washington and Oregon. | Kentucky. | Delaware and Maryland. | Iowa. | New Jersey. | Michigan. | Indiana. | Connecticut. | New York. | Wisconsin. | Total receipts. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mansfield, Ohio |  |  |  |  |  |  | 1 | 5 |  |  |  |  |  |  |  |  |  |  |  | 6 |
| Medina, N. Y |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  | 4 |
| Melrose, New York City |  |  |  |  |  |  |  |  |  |  |  | 3 |  |  |  |  |  |  |  | 3 |
| Middletown, Ohio |  |  |  |  |  |  |  | 3 |  |  |  |  |  |  |  |  |  |  |  | 3 |
| Milwaukee, Wis | 24 |  |  |  | 33 |  | 7 |  |  |  |  |  |  |  | 5 |  |  |  |  | 69 |
| Minneapolis, Minn | 42 |  |  | 33 | 71 |  | 8 | 1 |  | 15 |  |  | 14 |  |  |  |  |  | 3 | 187 |
| Mitchell, S. Dak |  |  |  | 1 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2 |
| Monarch, Pa |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  | 1 |
| Montreal, Quebeck | 25 |  | 5 |  |  |  | 1 |  |  |  |  | 56 |  |  |  |  |  |  |  | 87 |
| Moose Jaw, Saskatchewan |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  | 1 |
| Muncie, Ind |  |  |  |  |  |  | 4 | 8 |  |  |  |  |  |  |  |  |  |  |  | 12 |
| Muskegon, Mich |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| Muskogee, Okla | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| Newark, N. J |  |  | 61 |  |  | 11 |  |  |  |  |  | 76 |  | 86 |  |  |  |  |  | 234 |
| Newark, Ohio |  |  |  |  |  |  |  | 2 |  |  |  |  |  |  |  |  |  |  |  | 2 |
| New Bedford, Mass |  |  |  |  |  | 1 | 1 |  |  |  |  | 12 |  |  |  |  |  |  |  | 14 |
| New Britain, Conn |  |  |  |  |  |  |  |  |  |  |  | 1 |  | 2 |  |  |  |  |  | 3 |
| New Haven, Conn |  |  | 1 |  |  | 1 |  |  |  |  |  | 14 |  |  |  |  |  |  |  | 16 |
| New London, Conn |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  | 1 |
| New York, N. Y | 10 |  | 319 |  |  | 169 |  |  |  |  |  | 19 |  | 100 |  |  | 2 |  |  | 619 |
| North Adams, Mass |  |  | 1 |  |  | 2 | 3 |  |  |  |  | 9 |  | 3 |  |  |  |  |  | 18 |
| Norwich, Conn |  |  | 2 |  |  | 2 |  |  |  |  |  | 8 |  |  |  |  |  |  |  | 12 |
| Oelwein, Iowa |  |  |  | 3 |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  | 4 |
| Ogdensburg, N. Y |  |  |  |  |  |  | 1 |  |  |  |  | 21 |  |  |  |  |  |  |  | 22 |
| Oil City, Pa |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  | 5 |
| Oklahoma City, Okla | 8 |  |  |  | 6 |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  | 15 |
| Olean, N. Y |  |  | 2 |  |  |  | 1 |  |  |  |  | 9 |  |  |  |  |  |  |  | 12 |
| Omaha, Nebr | 41 |  |  | 6 | 52 |  | 2 |  |  | 10 |  |  |  |  |  |  |  |  |  | 111 |
| Oneonta, N. Y |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  | 1 |
| Ottawa, Ontario | 1 |  | 2 |  | 2 |  | 1 |  |  |  |  | 22 |  |  |  |  |  |  |  | 28 |
| Ottumwa, Iowa | 1 |  |  |  | 1 |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  | 4 |
| Parkersburg, W. Va |  |  |  |  |  |  | 3 | 1 |  |  |  |  |  |  |  |  |  |  |  | 4 |
| Paterson, N. J |  |  | 2 |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  | 7 |
| Peoria, Ill | 10 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 10 |
| Petersburg, Va |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  | 1 |
| Philadelphia, Pa | 3 |  | 136 |  |  | 55 |  |  |  |  |  | 41 |  | 65 |  |  |  |  |  | 300 |
| Phillipsburg, Pa |  |  |  |  |  |  |  |  |  |  |  | 29 |  | 31 |  |  |  |  |  | 60 |
| Pittsburgh, Pa | 42 | 6 | 41 | 1 | 3 | 7 | 36 | 32 |  |  | 31 | 149 |  | 5 |  |  |  | 6 |  | 359 |
| Pittsfield, Mass |  |  |  |  |  |  |  |  |  |  | 2 | 4 |  |  |  |  |  |  |  | 6 |
| Pocatello, Idaho |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  | 4 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Portage La Prairie, Manitoba | | | | | | | | | | 2 | | | | | | | | | | 2 |
| Portland, Me | | | 3 | | | 5 | 4 | | | | | 33 | | | | | 10 | | | 55 |
| Portsmouth, Ohio | | | | | | | | 2 | | | | | | | | | | | | 2 |
| Potomac Yard, Wash | | | 56 | | | | | | | | | | | | | | | | | 56 |
| Pottsville, Pa | | | | | | | | | | | | 3 | | | | | | | | 3 |
| Providence, R. I | 7 | | 14 | | | 20 | 1 | | | | | 49 | | 6 | | | | | | 97 |
| Pueblo, Colo | 1 | | | 2 | 8 | | | | 1 | | | | | | | | | | | 12 |
| Quincy, Ill | | | | | | | 1 | | | | | | | | | | | | | 1 |
| Reading, Pa | | | 1 | | | | | | | | | | | | | | | | | 1 |
| Regina, Saskatchewan | 2 | | | | | | | 1 | | | | | | | | | | | | 3 |
| Richmond, Ind | | | | | | | 3 | 5 | | | | | | | | | | | | 8 |
| Richmond, Va | | | 13 | | | | | | | | | | | | | | | | | 13 |
| Ridgley, Ind | | | | | | | | | | | | 1 | | | | | | | | 1 |
| Roanoke, Va | | | 7 | | | | | | | | | | | | | | | | | 7 |
| Rochester, N. Y | | | 3 | | | 2 | 6 | 2 | | | 1 | 102 | | 4 | | | | | | 120 |
| Rockford, Ill | 2 | | | | 2 | | 1 | | | | | | | | | | | | | 5 |
| Rouses Point, N. Y | | | | | | | | | | | | 7 | | | | | | | | 7 |
| Rugby, N. Dak | | | | | | | | | | 1 | | | | | | | | | | 1 |
| Rutland, Vt | | | | | | | | | | | | 3 | | 2 | | | | | | 5 |
| Saginaw, Mich | | | | | 1 | | | | | | | | | | 1 | | | | | 2 |
| St. Joseph, Mo | 2 | | | 5 | 7 | | | | | | | | | | | | | | | 14 |
| St. Louis, Mo | 58 | | | 151 | 13 | | 10 | | 4 | 1 | | | | | | | | | | 237 |
| St. Paul, Minn | 28 | | | 18 | 52 | | 4 | | | 6 | | | 6 | | | | | | | 114 |
| Salina, Kans | | | | | 9 | | | | | | | | | | | | | | | 9 |
| Salt Lake City, Utah | | | | | | | | | | 2 | | | | | | | | | | 2 |
| San Antonio, Tex | | | | | | | | | 4 | | | | | | | | | | | 4 |
| Saskatoon, Saskatchewan | | | | | | | | | | 1 | | | | | | | | | | 1 |
| Schenectady, N. Y | | | 2 | | | 1 | | | | | | 25 | | | | | | | | 28 |
| Scranton, Pa | | | 29 | | | | | | | | | 47 | | | | | | | | 76 |
| Seattle, Wash | 2 | | | | | | | | | | | | | | | | | | | 2 |
| Sydney, Ohio | | | | | | | | 3 | | | | | | | | | | | | 3 |
| Sioux City, Iowa | 13 | | | | 61 | | 1 | | | 5 | | | | | | | | | | 80 |
| Sioux Falls, S. Dak | 7 | | | | 5 | | 1 | | | 2 | | | | | | | | | | 15 |
| South Bend, Ind | 1 | | | | | | 2 | 9 | | | | | | | | | | | | 12 |
| Springfield, Ill | | | | 8 | 1 | | 6 | | | 2 | | | | | | | | | | 17 |
| Springfield, Mass | | | 10 | | | 3 | 1 | | | | | 26 | | 13 | | | | | | 58 |
| Springfield, Mo | | | | | | | | | 2 | | | | | | | | | | | 2 |
| Springfield, Ohio | 1 | 1 | | | | | 5 | 9 | | | 1 | | | | | | | | | 17 |
| Stamford, Conn | | | | | | | | | | | | 4 | | | | | | | | 4 |
| Staples, Minn | | | | | | | | | | 1 | | | | | | | | | | 1 |
| Steubenville, Ohio | | | | | | | 1 | | | | 1 | | | | | | | | | 2 |
| Syracuse, N. Y | | | 11 | | | 1 | 1 | | | | | 52 | | | | | | | | 65 |
| Terre Haute, Ind | | | | | | | 6 | 1 | | | | | | | | | | | | 7 |
| Thief River Falls, Minn | | | | | | | | | | 3 | | | | | | | | | | 3 |
| Toledo, Ohio | 5 | | | | | | 3 | 55 | | | | 1 | | | | | | | | 64 |
| Topeka, Kans | 5 | | | | 28 | | | | 3 | | | | | | | | | | | 36 |
| Toronto, Ontario | 3 | | 6 | | | | | 3 | | | | 66 | | | | | | | | 78 |
| Troy, N. Y | | | 9 | | | 1 | 1 | 1 | | | | 29 | | | | | | | | 41 |
| Troy, Ohio | | | | | | | | 5 | | | | | | | | | | | | 5 |
| Tulsa, Okla | 4 | | | | | | | | 1 | | | | | | | | | | | 5 |
| Utica, N. Y | | | | 1 | | | 2 | | | | | 20 | | | | | | | | 23 |

TABLE 2—Continued.

| Destination. | Louisiana. | Alabama. | Carolinas. | Arkansas. | Ozarks. | Virginia. | West Tennessee. | East Tennessee. | Texas. | Washington and Oregon. | Kentucky. | Delaware and Maryland. | Iowa. | New Jersey. | Michigan. | Indiana. | Connecticut. | New York. | Wisconsin. | Total receipts. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Valley City, N. Dak |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  | 1 |
| Vancouver, British Columbia |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  | 1 |
| Waco, Tex |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  | 1 |
| Wahpeton, N. Dak |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  | 1 |
| Washington, D. C |  |  | 38 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 38 |
| Washington Court House, Ohio |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  | 1 |
| Waterbury, Conn |  |  | 4 |  |  | 1 |  |  |  |  |  | 9 |  |  |  |  |  |  |  | 14 |
| Waterloo, Iowa | 1 |  |  | 6 | 8 |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  | 17 |
| Watertown, N Y |  |  | 1 |  |  | 1 | 2 |  |  |  |  | 40 |  |  |  |  |  |  |  | 44 |
| Watertown, S Dak |  |  |  | 1 |  |  |  |  |  | 8 |  |  | 1 |  |  |  |  |  |  | 10 |
| Watuppa, Mass |  |  | 2 |  |  | 3 |  |  |  |  |  | 3 |  |  |  |  |  |  |  | 8 |
| Waverly, N. Y |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  | 1 |
| Wheeling, W. Va |  |  |  |  |  |  | 3 | 11 |  |  | 1 | 5 |  |  |  |  |  |  |  | 20 |
| Wichita, Kans |  |  |  |  | 12 |  |  |  | 6 |  |  |  |  |  |  |  |  |  |  | 18 |
| Wilkes-Barre, Pa |  |  | 10 |  |  | 2 |  |  |  |  |  | 34 |  |  |  |  |  |  |  | 46 |
| Williamsport, Pa |  |  | 5 |  |  |  |  |  |  |  |  | 2 |  |  |  |  |  |  |  | 7 |
| Wilmington, Del |  |  | 11 |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  | 16 |
| Winnipeg, Manitoba | 13 |  |  |  |  |  | 1 |  |  | 25 |  |  |  |  |  |  |  |  |  | 39 |
| Winona, Minn |  |  |  | 2 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 3 |
| Worcester, Mass | 3 |  | 5 |  |  | 4 | 5 |  |  |  |  | 30 |  | 8 |  |  |  |  |  | 55 |
| Yorktown, Saskatchewan |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  | 1 |
| Youngstown, Ohio |  |  |  |  |  |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  | 2 |
| Zanesville, Ohio |  |  |  |  |  |  | 2 | 6 |  |  |  |  |  |  |  |  |  |  |  | 8 |
| Various points |  |  |  |  | 109 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 109 |
| Total | 1,335 | 314 | 1,042 | 297 | 899 | 405 | 506 | 693 | 57 | 191 | 150 | 2,226 | 44 | 1,291 | 12 | 10 | 174 | 6 | 12 | 9,664 |

## TOTAL STRAWBERRY SHIPMENTS IN 1915.

Reports from the railroads at the end of the strawberry season were received by the Office of Markets and Rural Organization and have been tabulated in Table 3. This table shows the strawberry-shipping stations and the actual number of cars shipped from each during the 1915 season. They are grouped by States and by shipping districts and represent the final figures obtainable for shipments during the year.

TABLE 3.—*Strawberry shipments, 1915.*

| | Carloads. |
|---|---|
| ALABAMA. | |
| Castleberry section (Apr. 15 to June 1): | |
| Castleberry | 47 |
| Atmore | 21 |
| Bolling | 4 |
| Total | 72 |
| York section (Apr. 15 to June 1): | |
| Cuba | 42 |
| York | 23 |
| Livingston | 4 |
| McConnell | 1 |
| Total | 70 |
| Cullman section (Apr. 15 to June 5): | |
| Cullman | 65 |
| Hanceville | 22 |
| Total | 87 |
| Thorsby section (Apr. 20 to June 1): | |
| Thorsby | 22 |
| Total | 22 |
| State total | 251 |
| ARKANSAS. | |
| Southwest section (Apr. 25 to June 1): | |
| Horatio | 14 |
| Cauthorn | 6 |
| Total | 20 |
| Judsonia section (Apr. 25 to June 5): | |
| Judsonia | 187 |
| Bald Knob | 66 |
| McRae | 31 |
| Searcy | 25 |
| Morrillton | 17 |
| Dardanelle | 8 |
| Leslie | 7 |
| Higginson | 5 |
| Bradford | 4 |
| Jonesboro | 3 |
| Pangburn | 2 |
| Marshall | 1 |
| Total | 356 |
| Ozark section (May 1 to June 5): | |
| Van Buren | 45 |
| Springdale | 40 |
| Johnsons | 39 |
| Alma | 36 |
| Farmington | 35 |
| Fayetteville | 31 |
| Decatur | 15 |
| Highfill | 14 |
| Dyer | 12 |
| Rudy | 11 |
| Mountainburg | 10 |
| Mulberry | 9 |
| Cave Springs | 8 |
| Tontitown | 8 |
| Avoca | 6 |
| Siloam Springs | 6 |
| Elm Springs | 4 |
| Garfield | 4 |
| Healing Springs | 3 |
| Litteral | 2 |
| Gentry | 1 |
| Total | 339 |
| State total | 715 |
| CALIFORNIA. | |
| Los Angeles section (Mar. 1 to Dec. 1): | |
| Gardena | [a] 27 |
| Total | 27 |
| Sacramento section (Mar. 25 to Aug. 15): | |
| Sacramento | 50 |
| Florin | 48 |
| Total | 98 |
| Placer County section (Apr. 1 to June 1): | |
| New Castle | 3 |
| Total | 3 |
| Fresno section (Apr. 1 to Aug. 15): | |
| Fresno | 56 |
| Total | 56 |
| Santa Clara-Santa Cruz section (Apr. 1 to Dec. 1): | |
| Alviso | * 175 |
| Watsonville | 174 |
| Aromas and Vegas | 80 |
| Gilroy | 6 |
| Total | 435 |

[a] Probably a large additional amount shipped locally on trucks and electric lines.

* Includes less than carload shipments.

TABLE 3.—*Strawberry shipments, 1915*—Continued.

| | Carloads. |
|---|---|
| CALIFORNIA—Continued. | |
| Siskiyou section (May 20 to July 15): | |
| Sisson | 16 |
| Total | 16 |
| State total | 418 |
| COLORADO. | |
| Montrose | 7 |
| Steamboat Springs | 2 |
| State total | 9 |
| CONNECTICUT. (June 15 to July 1.) | |
| Branford | 33 |
| New Haven | 5 |
| State total | 38 |
| DELAWARE. (May 15 to June 20.) | |
| Selbyville | 654 |
| Bridgeville | 348 |
| Seaford | 89 |
| Frankford | 69 |
| Millsboro | 53 |
| Georgetown | 51 |
| Laurel | 41 |
| Wyoming | 41 |
| Lincoln City | 34 |
| Greenwood | 29 |
| Dagsboro | 26 |
| Delmar | 19 |
| Hartly | 7 |
| Cannon | 4 |
| Cheswold | 4 |
| State total | 1,469 |
| FLORIDA. | |
| Plant City section (Dec. 1 to Apr. 1): | |
| Plant City | 201 |
| Lakeland | 21 |
| Total | 222 |
| Starke section (Feb. 10 to May 15): | |
| Lawtey | 160 |
| Starke | 115 |
| Hampton | 9 |
| Raiford | 2 |
| Total | 286 |
| State total | 508 |
| GEORGIA. (May 1 to June 1.) | |
| Menlo | 3 |
| State total | 3 |
| ILLINOIS. (May 15 to June 20.) | |
| Anna | 100 |
| Villa Ridge | 50 |
| Farina | 41 |
| West Frankfort | 39 |
| Joppa | 21 |
| ILLINOIS—Continued. | |
| La Clede | 10 |
| Ullin | 1 |
| State total | 262 |
| INDIANA. (May 25 to June 25.) | |
| New Albany | *112 |
| Borden | *53 |
| Pekin | *6 |
| State total | [a] 171 |
| IOWA. (June 1 to June 20.) | |
| Montrose | 26 |
| Keokuk | 24 |
| Ottumwa | 2 |
| State total | 52 |
| KANSAS. (May 20 to June 20.) | |
| Troy | 10 |
| Wathena | 6 |
| State total | 16 |
| KENTUCKY (May 10 to June 10). | |
| Bowling Green | 156 |
| Louisville | *33 |
| Paducah | 4 |
| State total | [a] 193 |
| LOUISIANA (Mar. 15 to May 20). | |
| Independence | *405 |
| Hammond | *362 |
| Amite | *116 |
| Ponchatoula | *190 |
| Tickfaw | *103 |
| Mason | *18 |
| Pickups | *206 |
| State total | 1,400 |
| MARYLAND (May 15 to June 30). | |
| Marion | 486 |
| Pittsville | 315 |
| Fruitland | 139 |
| Princess Anne | 101 |
| Berlin | 98 |
| Showell | 90 |
| Hopewell | 77 |
| Willards | 73 |
| Ridgely | 66 |
| Westover | 55 |
| Whaleysville | 54 |
| Federalsburg | 50 |
| Crisfield | 26 |
| Eden | 22 |
| Baltimore | 18 |
| Costen | 17 |
| Pocomoke | 16 |
| Walstons | 11 |
| Salisbury | 7 |
| Kings Creek | 6 |
| East New Market | 6 |
| Henderson | 5 |
| Kingston | 4 |

* Includes less than carload shipments.

[a] 97 cars from Indiana and 12 from Kentucky were express, and contained small quantities of commodities other than strawberries.

TABLE 3.—*Strawberry shipments, 1915*—Continued.

| MARYLAND—Continued. | Carloads. |
|---|---|
| Loretto | 2 |
| Mardella Springs | 1 |
| Boat pickups | 198 |
| State total | [a]1,942 |
| MASSACHUSETTS (June 20 to July 15). | |
| Falmouth | 97 |
| North Falmouth | 2 |
| Watuppa | 1 |
| State total | 100 |
| MICHIGAN (June 1 to July 18). | |
| Benton Harbor, St. Joseph | 118 |
| South Haven | 66 |
| Muskegon | 54 |
| Bridgman | 33 |
| Grand Haven | 27 |
| Bailey | 2 |
| Glendora | 2 |
| Whitehall | 2 |
| Michillinda | 1 |
| Sault Ste. Marie | 1 |
| Boat pickups | [b]11 |
| State total | 317 |
| MISSISSIPPI. | |
| Southern Osyka section (Apr. 10 to May 15): | |
| Osyka | 19 |
| Total | 19 |
| Sanford section (Apr. 10 to May 15): | |
| Sanford | 33 |
| Total | 33 |
| Lauderdale section (Apr. 15 to June 1): | |
| Russell | 30 |
| Total | 30 |
| Central Durant section (Apr. 20 to May 20): | |
| Madison | 31 |
| Durant | 28 |
| Jackson | 16 |
| Ridgeland | 12 |
| Total | 87 |
| State total | 169 |
| MISSOURI (May 15 to June 20). | |
| Neosho | 127 |
| Sarcoxie | 118 |
| Monett | 95 |
| Pierce City | 64 |
| Anderson | 47 |
| Butterfield | 42 |
| Logan | 41 |
| Republic | 21 |
| Stark City | 19 |
| Purdy | 18 |
| Goodman | 14 |
| Marionville | 11 |
| Carthage | 8 |
| Seneca | 8 |
| Wheaton | 6 |

| MISSOURI—Continued. | Carloads. |
|---|---|
| Verona | 4 |
| Mount Vernon | 2 |
| State total | 645 |
| NEW HAMPSHIRE (July). | |
| Manchester | 1 |
| State total | 1 |
| NEW JERSEY (May 25 to June 25). | |
| Port Norris | 90 |
| Landisville | 75 |
| Rosenhayn | 66 |
| Cedarville | 58 |
| Pedricktown | 31 |
| Hammonton | 26 |
| Mauricetown | 22 |
| Fairton | 20 |
| Egg Harbor | 19 |
| Richland | 15 |
| Newport | 14 |
| Norma | 14 |
| Leesburg | 13 |
| Cologne | 9 |
| West Moorestown | 9 |
| Vineland | 8 |
| Cedar Brook | 7 |
| Waterford | 7 |
| Belleplain | 5 |
| Elwood | 3 |
| Penns Grove | 3 |
| Newfield | 1 |
| Woodbine | 1 |
| State total | 516 |
| NEW YORK (June 1 to July 1). | |
| Scriba | 38 |
| Milton | 32 |
| Angola | 31 |
| New Haven | 26 |
| Oswego | 26 |
| Marlborough | 25 |
| Roseton | 9 |
| Mexico | 8 |
| Ripley | 1 |
| State total | 196 |
| NORTH CAROLINA (Apr. 15 to June 1). | |
| Chadbourn | 210 |
| Mount Tabor | 160 |
| Teacheys | 100 |
| Rose Hill | 98 |
| Mount Olive | 95 |
| Whiteville | 39 |
| Clarendon | 36 |
| Rocky Point | 33 |
| Wallace | 23 |
| Bladenboro | 16 |
| Faison | 13 |
| Willard | 8 |
| Abbottsburg | 6 |
| State total | 837 |

[a] Maryland boat pickups include Virginia pickups from the eastern shore of Chesapeake Bay.

[b] Pickups from eastern shore of Lake Michigan.

TABLE 3.—*Strawberry shipments, 1915*—Continued.

| | Carloads. |
|---|---|
| **OHIO (June 1 to June 25).** | |
| Leetonia | 17 |
| Perry | 9 |
| Marietta | 6 |
| Cincinnati | 1 |
| Lodi | 1 |
| State total | 34 |
| **OREGON (May 25 to July 15).** | |
| Hood River | 193 |
| State total | 193 |
| **PENNSYLVANIA (June 1 to July 1).** | |
| North East | 74 |
| Stoneboro | 6 |
| Scranton | 1 |
| State total | 81 |
| **SOUTH CAROLINA (Apr. 12 to May 25).** | |
| Loris | 82 |
| Conway | 2 |
| State total | 84 |
| **SOUTH DAKOTA (June 15 to July 15).** | |
| Sioux Falls | 1 |
| State total | 1 |
| **TENNESSEE.** | |
| Chattanooga section (May 1 to June 5): | |
| Dayton | 155 |
| Evensville | 142 |
| Spring City | 140 |
| Sale Creek | 37 |
| Bakewell | 34 |
| Knoxville | 32 |
| Sheffield | 24 |
| Chattanooga | 19 |
| Boyce | 16 |
| Lancing | 10 |
| Graysville | 4 |
| Rathburn | 4 |
| Rockwood | 3 |
| Total | 620 |
| Dyer-Sharon-Humboldt section (May 1 to June 5): | |
| Humboldt | 252 |
| Medina | 71 |
| Dyer | 63 |
| Sharon | 56 |
| Gates | 47 |
| Kenton | 46 |
| Jackson | 45 |
| Curve | 39 |
| Ripley | 36 |
| Gadsden | 33 |
| Bells | 29 |
| Halls | 17 |
| Trezevant | 16 |
| Grand Junction | 15 |
| Milan | 12 |
| **TENNESSEE—Continued.** | |
| Dyer-Sharon-Humboldt section—Contd. | |
| Dresden | 12 |
| Greenfield | 12 |
| Portland | 8 |
| Trenton | 8 |
| Bradford | 6 |
| Gibson | 6 |
| Obion | 6 |
| Nashville | 4 |
| Total | 839 |
| State total | 1,459 |
| **TEXAS.** | |
| Alvin Section (Mar. 1 to May 15): | |
| Deepwater | 81 |
| Alvin | 47 |
| Dickinson | 20 |
| Houston | 11 |
| Total | 159 |
| Artesian Belt section (Mar. 1 to May 15): | |
| Carrizo Springs | 14 |
| Total | 14 |
| Tyler section (Apr. 1 to May 10): | |
| Winnsboro | 41 |
| Tyler | 33 |
| Lindale | 15 |
| North Jefferson | 6 |
| Jefferson | 6 |
| Swan | 6 |
| Hawkins | 2 |
| Marshall | 2 |
| Total | 111 |
| Brownsville section (Mar. 15 to May 1): | |
| San Benito | 1 |
| Total | 1 |
| State total | 285 |
| **UTAH (June 5 to July 1).** | |
| Provo | 4 |
| State total | 4 |
| **VIRGINIA.** | |
| Norfolk section (May 1 to June 1) | 444 |
| Total | 444 |
| Eastern shore section (May 5 to June 5): | |
| Onley | 61 |
| Mears | 29 |
| Parksley | 22 |
| Tasley | 20 |
| Keller | 19 |
| Melfa | 17 |
| Painter | 12 |
| Makemie Park | 10 |
| Lecato | 6 |
| Total | [a] 196 |
| State total | 640 |

[a] This does not include Norfolk section.

TABLE 3.—*Strawberry shipments, 1915*—Continued.

WASHINGTON (May 20 to July 15)

| | Carloads. |
|---|---|
| White Salmon | 40 |
| Spokane | 30 |
| Kennewick | 29 |
| Seattle | 26 |
| Edmonds | 5 |
| Lynden | 3 |
| Bellingham | 2 |
| Tacoma | 2 |
| Centralia | 2 |
| Auburn | 1 |
| North Yakima | 1 |
| Richmond Beach | 1 |
| State total | 142 |

WISCONSIN (June 5 to July 15).

| | Carloads. |
|---|---|
| Racine | 21 |
| Bayfield | 10 |
| Sturgeon Bay | 10 |
| State total | 41 |
| Grand total | 13,409 |

Owing to the fact that certain well-known commercial strawberry areas do not lie entirely within State borders, the following tabulation gives certain shipments on a district rather than on a State basis. The data given below are included in the grand total and are simply a rearrangement of some of the material included under State headings.

TABLE 4.—*Supplementary tabulation of strawberry shipments in 1915 by districts.*

PENINSULAR SECTION (May 10 to June 15).

| | Carloads. |
|---|---|
| Selbyville, Del | 654 |
| Marion, Md | 486 |
| Bridgeville, Del | 348 |
| Pittsville, Md | 315 |
| Fruitland, Md | 139 |
| Princess Anne, Md | 101 |
| Berlin, Md | 98 |
| Showell, Md | 90 |
| Seaford, Del | 89 |
| Hopewell, Md | 77 |
| Willards, Md | 73 |
| Frankford, Del | 69 |
| Ridgely, Md | 66 |
| Onley, Va | 61 |
| Westover, Md | 55 |
| Whaleysville, Md | 54 |
| Millsboro, Del | 53 |
| Georgetown, Del | 51 |
| Federalsburg, Md | 50 |
| Laurel, Del | 41 |
| Wyoming, Del | 41 |
| Lincoln City, Del | 34 |
| Greenwood, Del | 29 |
| Mears, Va | 29 |
| Dagsboro, Del | 26 |
| Crisfield, Md | 25 |
| Eden, Md | 22 |
| Parksley, Va | 22 |
| Tasley, Va | 20 |
| Delmar, Del | 19 |
| Keller, Va | 19 |
| Coston, Md | 17 |
| Melfa, Va | 17 |
| Pocomoke, Md | 16 |
| Painter, Va | 12 |
| Walstons, Md | 11 |
| Makemie Park, Va | 10 |
| Hartley, Del | 7 |
| Salisbury, Md | 7 |
| East New Market, Md | 6 |
| Kings Creek, Md | 6 |
| Lecato, Va | 6 |
| Henderson, Md | 5 |
| Cannon, Del | 4 |
| Cheswold, Del | 4 |
| Kingston, Md | 4 |
| Loretto, Md | 2 |
| Mardella Springs, Md | 1 |
| Boat pickups, Maryland and Virginia | 198 |
| Total | 3,589 |

OZARK SECTION (May 1 to June 15).

| | |
|---|---|
| Neosho, Mo | 127 |
| Sarcoxie, Mo | 118 |
| Monett, Mo | 95 |
| Pierce City, Mo | 64 |
| Anderson, Mo | 47 |
| Van Buren, Ark | 45 |
| Butterfield, Mo | 42 |
| Logan, Mo | 41 |
| Springdale, Ark | 40 |
| Johnsons, Ark | 39 |
| Alma, Ark | 36 |
| Farmington, Ark | 35 |
| Fayetteville, Ark | 31 |
| Republic, Mo | 21 |
| Stark City, Mo | 19 |
| Purdy, Mo | 18 |
| Decatur, Ark | 15 |
| Goodman, Mo | 14 |
| Highfill, Ark | 14 |
| Dyer, Ark | 12 |
| Marionville, Mo | 11 |
| Rudy, Ark | 11 |
| Mountainburg, Ark | 10 |

TABLE 4.—*Supplementary tabulation of strawberry shipments in 1915 by districts*—Con.

OZARK SECTION—Continued.

| | Carloads. |
|---|---|
| Mulberry, Ark | 9 |
| Carthage, Mo | 8 |
| Cave Springs, Ark | 8 |
| Seneca, Mo | 8 |
| Tontitown, Ark | 8 |
| Avoca, Ark | 6 |
| Siloam Springs, Ark | 6 |
| Wheaton, Mo | 6 |
| Elm Springs, Ark | 4 |
| Garfield, Ark | 4 |
| Verona, Mo | 4 |
| Healing Springs, Ark | 3 |
| Litteral, Ark | 2 |
| Mount Vernon, Mo | 2 |
| Gentry, Ark | 1 |
| Total | 984 |

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 478

Joint Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief, and the Office of Markets and
Rural Organization, CHARLES J. BRAND, Chief

**Washington, D. C.** ▼ **December 30, 1916**

# THE ORIGIN, CHARACTERISTICS, AND QUALITY OF HUMPBACK WHEAT.[1]

By LEVI M. THOMAS, *Assistant in Charge of the United States Grain-Standardization Laboratory at Fargo, N. Dak.*

## INTRODUCTION.

The term Humpback is applied to a strain of wheat which is being grown to an increasing extent in Minnesota and to a limited extent in the Dakotas. This wheat has found favor with the producers because of the large yields claimed for it, but it is generally discriminated against by the grain trade because of its alleged inferior milling qualities.

This strain of wheat is said to be the result of a field selection by J. P. Berglund, a farmer living near Kensington, Minn., who about 18 years ago found, growing in a field of Bluestem wheat, a plant distinguished from the rest of the field by bearded heads and a more vigorous growth. The seed from this plant was saved and planted separately, producing a strain of wheat known as Humpback, which wheat was first distributed among the Kensington farmers 11 or 12 years ago. It was originally called Bearded Bluestem, a name given to it by Mr. Berglund because it has the characteristic velvety chaff of Bluestem, but it soon earned the more popular name of Humpback, owing to the peculiar shape of the kernels, the dorsal side being characterized by a prominence immediately to the rear of the germ and a curved slope toward the brush, making the term Humpback quite descriptive.[2] The term Marvel, and perhaps other names, has been applied to this variety by distributors of the seed.

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[1] The investigations reported herein were made by the Office of Grain Standardization of the Bureau of Plant Industry. Since August 18, 1916, the grain-standardization work of the Department of Agriculture has been administered jointly by the Office of Markets and Rural Organization and the Bureau of Plant Industry in connection with the administration of the United States Grain Standards Act.

The data contained in this bulletin represent the results of investigations made by Mr. Levi M. Thomas, in charge of the Grain-Standardization Laboratory at Fargo, where special investigations are being carried on in cooperation with the North Dakota Agricultural Experiment Station relative to the milling and baking value of different classes and grades of wheat.

[2] Certain eastern soft-wheat varieties have this same characteristic to fully as marked a degree as the Humpback. The variety known as Rural New Yorker No. 57 is especially similar to the Humpback in all general characters.

NOTE.—This bulletin will be of interest to millers and grain dealers in the States of North Dakota, South Dakota, Minnesota, and Montana, and to the grain exchanges and inspection departments in the various markets.

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Care should be taken not to confuse Humpback wheat with the more widely grown varieties of the Northwest, commonly, though incorrectly, known as Velvet Chaff. The Velvet Chaff wheats, sometimes classified as the Preston group, are bearded but are of the Red Fife type, and the kernels are much smaller than those of the Humpback, approaching closer to the Fife and Bluestem wheats in size and quality. Another point of difference is apparent in the heads of the wheat. Humpback wheat has, as already stated, a velvety chaff, while curiously enough the bearded spring wheats, commonly known as Velvet Chaff, are characterized not by a velvety but by a smooth chaff. The comparative shape and size of Humpback, Velvet Chaff, Glyndon Fife (Minnesota No. 163), and Bluestem wheats are shown, natural size, in Plate I.

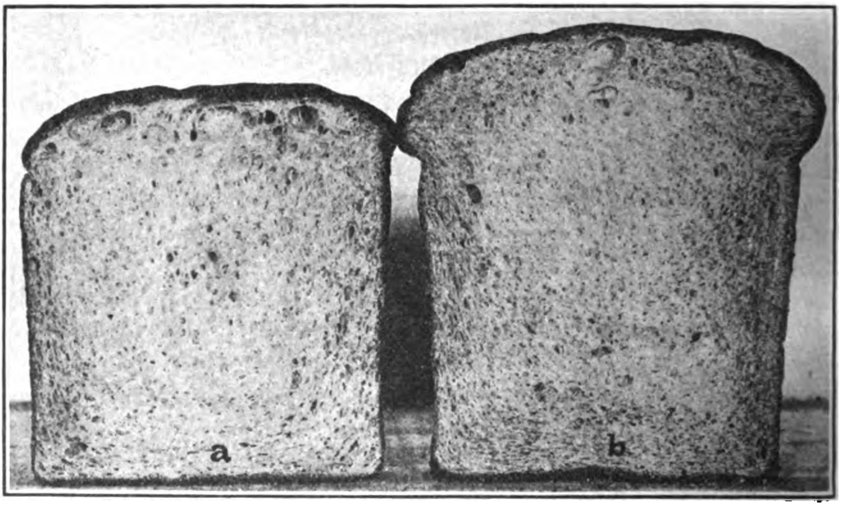


FIG. 1.—Bread made from samples of Humpback and Bluestem wheats grown near Glenwood, Minn., in 1913: *a*, Loaf from Humpback wheat, yielding 73 per cent of straight flour and having a loaf volume of 1,970 cubic centimeters and a texture score of 87.5; *b*, loaf from Bluestem wheat, yielding 74 per cent of straight flour and having a loaf volume of 2,445 cubic centimeters and a texture score of 93.5.

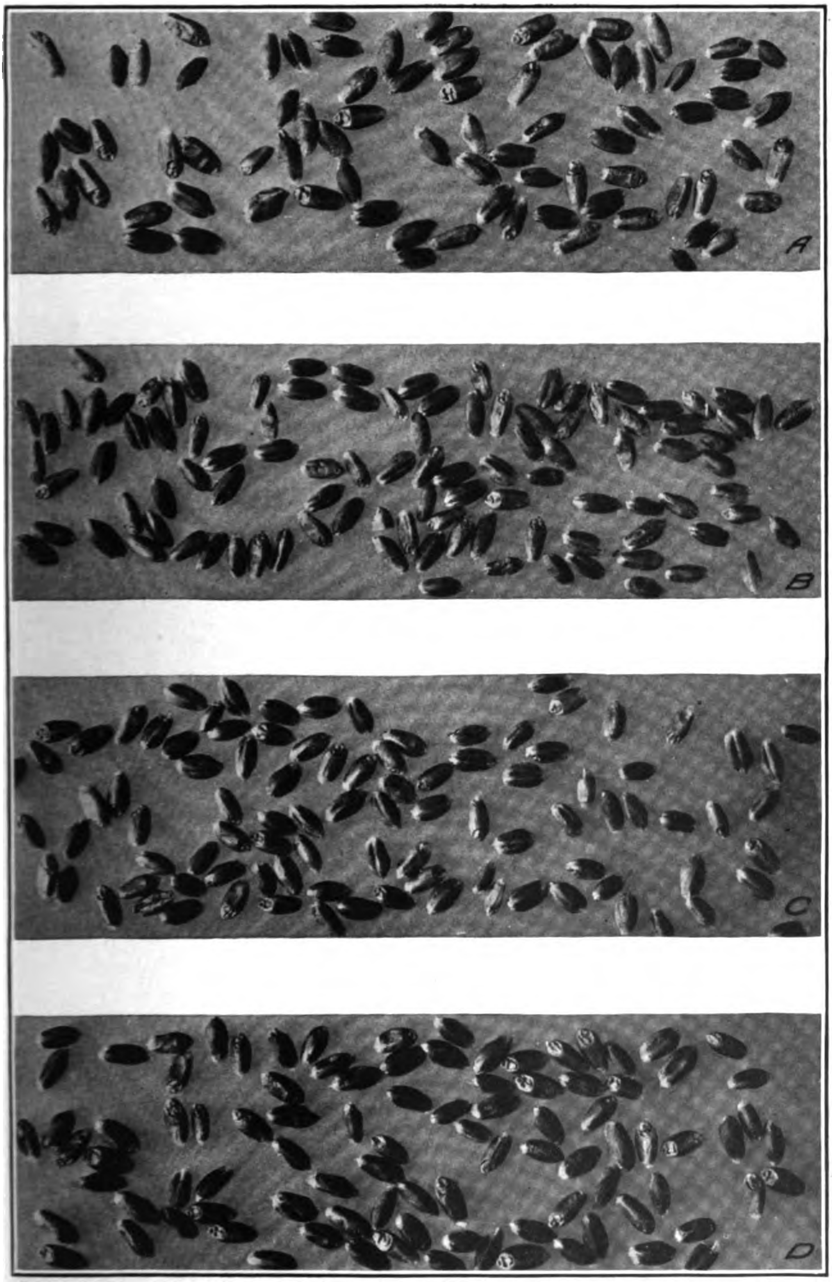
Humpback wheat has a large berry as compared with most strains of the hard spring wheats, in point of size being midway between the common varieties of spring wheat and the durums. The kernels are of a dark amber color and are perhaps a little softer than most wheats of this class. The weight per bushel will be found to range somewhat higher than the Fife and Bluestem wheats, the average of nine samples from the 1910 crop being over 60 pounds per bushel.

## MILLING AND BAKING QUALITIES.[1]

Table I gives the comparative results of the milling and baking qualities of a limited number of samples of Humpback and other

---

[1] The Minnesota State grain-inspection department under the grade rules for northern spring wheat specifies that "the variety known as 'Humpback,' owing to its inferior milling quality, shall not be graded higher than No. 3."



TYPE SAMPLES OF SOME OF THE SPRING WHEATS: *A*, HUMPBACK; *B*, VELVET CHAFF; *C*, GLYNDON FIFE (MINNESOTA NO. 163); *D*, BLUESTEM. (NATURAL SIZE.)

hard spring wheats. Attention is called to the fact that the results on the Humpback wheat, as shown in the table, include tests of samples representing the crops of the three years, 1908, 1909, and 1910. The crops of 1908 and 1909 are represented by one sample each, and the crop of 1910 by nine samples. Five of the samples of the 1910 crop were secured near Hoffman, Minn., and the remaining four from near Kensington, Minn. At each of these points a sample of Bluestem wheat was also obtained, the results of milling and baking tests upon the same being likewise shown in Table I. The figures at the bottom of the table give the average of tests of Bluestem and Velvet Chaff wheats from North Dakota and Minnesota of the 1910 crop and afford an interesting comparison with the Humpback wheat, to the disadvantage of the latter. With the exception of samples 255 and 502, the results as given in the table are based on the yield of "straight flour," the tests on these two samples being on the patent flour.

TABLE I.—*Comparison of results of milling and baking tests of Humpback wheats with other hard red spring wheats.*

| Description and source of sample. | No. | Yield of straight flour. | Volume of loaf— Per 340 grams of flour. | Volume of loaf— Per 100 grams of flour. | Absorption (water used per 100 grams of flour). | Color of crumb. | Crude protein (N × 5.7). In flour. | Crude protein (N × 5.7). In wheat. |
|---|---|---|---|---|---|---|---|---|
| Humpback wheat from— | | *Per ct.* | *C. c.* | *C. c.* | *C. c.* | *Score.* | *Per ct.* | *Per ct.* |
| Kensington, Minn., crop of 1908 | [1] 255 | [1] 70.82 | 2,138 | 629 | 51.8 | 96 | 12.31 | 12.31 |
| Kensington, Minn., crop of 1909 | [1] 502 | [1] 69.7 | 2,260 | 681 | 51.5 | 91 | 11.91 | 12.71 |
| Hoffman, Minn., crop of 1910 | 637 | 65.6 | 2,230 | 656 | 51.8 | 91 | 12.77 | 14.19 |
| Do | 700 | 68.7 | 2,400 | 706 | 50.6 | 97 | 14.65 | 14.88 |
| Do | 701 | 72.6 | 2,100 | 618 | 50.0 | 96 | 13.97 | 14.82 |
| Do | 702 | 72.5 | 2,010 | 591 | 50.0 | 95 | 14.99 | 15.79 |
| Do | 703 | 69.7 | 2,150 | 632 | 50.0 | 95 | 14.54 | 15.16 |
| Kensington, Minn., crop of 1910 | 704 | 72.8 | 2,150 | 632 | 50.0 | 96 | 12.60 | 12.77 |
| Do | 705 | 72.4 | 2,120 | 624 | 49.7 | 96 | 13.34 | 14.02 |
| Do | 706 | 72.8 | 2,090 | 615 | 48.2 | 95 | 13.05 | 13.22 |
| Do | 708 | 73.4 | 2,050 | 603 | 48.2 | 95 | 13.91 | 14.36 |
| Bluestem wheat from— | | | | | | | | |
| Hoffman, Minn., crop of 1910 | 699 | 69.5 | 2,590 | 762 | 52.4 | 98 | 14.36 | 14.82 |
| Kensington, Minn., crop of 1910 | 707 | 73.2 | 2,260 | 665 | 50.3 | 97 | 14.02 | 13.91 |
| AVERAGES. | | | | | | | | |
| Humpback wheats from— | | | | | | | | |
| Hoffman, Minn., crop of 1910 | ...... | 69.8 | 2,176 | 640 | 50.5 | 94.8 | 14.19 | 14.95 |
| Kensington, Minn., crop of 1910 | ...... | 72.9 | 2,105 | 619 | 49.0 | 95.5 | 13.23 | 13.59 |
| Both Hoffman and Kensington, crop of 1910 | ...... | 71.2 | 2,145 | 631 | 49.8 | 95.1 | 13.76 | 14.35 |
| Eight samples of Bluestem wheat from North Dakota and Minnesota, crop of 1910 | ...... | 69.2 | 2,430 | 715 | 52.1 | 97.1 | 12.59 | 13.4 |
| Seventeen samples of Velvet Chaff wheat, grown in North Dakota, 1910 | ...... | 66.9 | 2,428 | 713 | 52.4 | 99 | 13.37 | 14.52 |

[1] With samples 255 and 502 the tests were made on the patent flour, but in all other cases on the straight flour.

From the standpoint of flour yield, as obtained upon the experimental mill of the North Dakota Agricultural Experiment Station, it will be noticed that the Humpback wheat, like other large-berried varieties, gives a high yield of flour, in this respect probably excelling the smaller berried varieties. However, in the study of the next three columns in the table we do not find that the figures speak so well for the Humpback wheat. The volume of the loaf, which is the approximate expression of the "baking strength" of the flour, in all cases falls well below the average for the spring wheats. A comparison of the results of the absorption, or the amount of water used in making the dough, does not show such striking differences, but most of the samples fall below the average in this respect. In color of crumb, which is a factor of considerable importance to the baking trade, it will be noticed that the bread made from the Humpback wheat flour is not up to the standard. Figure 1 shows the actual differences in loaves produced from samples of Humpback and Bluestem wheat grown near Glenwood, Minn., in 1913.

The figures in the last two columns of the table, showing crude protein in the wheat and the flour, are interesting. It will be noted that here we have a point of resemblance between the Humpback and the durum wheat, as the Humpback wheat averages high in crude protein and yet is low in "baking strength."

## CONCLUSIONS.

In conclusion, the principal points may be briefly stated as follows:

Humpback wheat is a bearded spring wheat characterized by a velvety chaff. This wheat should not be confused with the so-called Velvet Chaff wheats of the Northwest, which are bearded spring wheats of the Red Fife type and have a smooth chaff.

Humpback wheat has a large berry, somewhat soft in texture, giving a high yield of flour. The weight per bushel of this wheat is higher than that of Bluestem wheat.

The flour from the samples of Humpback wheat was lower in baking strength and general quality than the flour from the other spring wheats which were tested.

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HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER May 31, 1917

# NURSERY PRACTICE ON THE NATIONAL FORESTS

By

C. R. TILLOTSON, Forest Examiner

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## INTRODUCTION.

Each year about 10,000,000 forest-tree seedlings or transplants are required for the reforestation operations on the National Forests. The stock supplied for these operations must be of the proper size and species, of high grade, and available for use on very short notice. Furthermore, production of the stock under seasonal conditions corresponding as closely as possible to those at the planting site is desirable. In order that these requirements may be met and that at the same time the stock may be produced at a low cost it is necessary not only that the nurseries be properly located and of the right size, but also that efficient and economical methods of nursery practice be employed.

## FACTORS INFLUENCING SELECTION OF A NURSERY SITE.

Choosing a site for a large nursery is difficult, especially in a mountainous country, where all of the conditions favorable to nursery operations are seldom encountered on one area. The principal factors to be considered are: (1) The water supply; (2) the soil; (3) the amount of land available; (4) the exposure and slope of the site; (5) its accessibility; (6) the species of stock to be raised; (7) the nature of the surroundings; (8) the cover of the site; and (9) the climate.

---

[1] This bulletin represents the results of the study and experience of many different members of the Forest Service. The author's part has been to compile, weigh, and harmonize these results. The collection of forest-tree seed and field seedling and planting are covered in Bulletin No. 475 of the U. S. Department of Agriculture, "Reforestation on the National Forests."

NOTE.—This bulletin should prove of interest and value to all who are engaged in nursery work with forest trees.

### WATER SUPPLY.

Plants grown in nurseries are subjected to unfavorable conditions of crowding and often of climate not encountered under natural conditions. Yet an effort must be made to keep the mortality rate as low as possible and to produce good stock for field planting. For these reasons it is essential in selecting a site for a nursery to choose one where there is an abundant supply of water.

The amount of water necessary depends upon the size of the nursery and its possible future extension, the method followed in watering, the amount and distribution of rainfall, and the character of the soil. A very porous, well-drained soil will require a greater supply of water than a heavier, more retentive one. If open-ditch irrigation of the beds is practiced a greater supply will be necessary, because of seepage, than if the water is conveyed in pipes and distributed by sprinklers. If the rainfall were evenly distributed and sufficient for all needs of the plants it would, of course, eliminate the necessity of a water supply. This condition seldom exists. While abundant precipitation may occur during a portion of the growing season, there is almost certain to be a dry period when artificial watering will be necessary and when a supply as abundant for the time being as if the whole year were dry will be needed.

In every case the amount of water available during the period of low water and, if possible, the minimum flow during extremely dry years should be ascertained. Where water is in urgent demand for irrigation purposes, it is vitally important to know whether there is, during dry seasons, sufficient unappropriated water in a stream under consideration, and what the State laws are regarding its use.

At the Savenac Nursery, where ditch irrigation is practiced, at the Bessey Nursery, where flooding of the beds is practiced, and at the Wind River Nursery, where garden sprinklers are used entirely, about 4,800, 225, and 75 gallons of water per minute are available, respectively. The yearly capacity of the nurseries is 4,000,000, 2,000,000, and 2,000,000 plants, and the areas actually occupied by nursery stock are about 15, 3, and 4 acres, respectively. Except possibly in the case of the Savenac Nursery, the amount of water available is not more than is desirable for successful nursery operations.

Where it is intended to use garden sprinklers, it is well to know that, under good water pressure, either the rotary or stationary type of these sprinklers throws from 4 to 6 gallons of water per minute.

When the spray falls in a 10-foot radius, this equals from 1.3 to 1.9 inches of rainfall per hour. It may occasionally be necessary to use 10 or 12 sprinklers at one time, which means that there must be available at least from 40 to 75 gallons of water per minute.

## SOIL.

In choosing the location for a nursery, soil possessing the best chemical and physical properties should be selected. Forest Service experience has not indicated that it should resemble the soil of the planting site, especially where that is poor. Plants grown in poor soil, particularly dry soil, are forced to extend their roots in search of moisture; and when such plants are removed from the nursey the fine feeding roots are almost certain to be cut off and the stock rendered less fit for field planting. Thrifty plants with a normal root development grown on good soil generally offer the best chance for success.

The soil should be sufficiently fertile; but desirable physical qualities, such as moderate freshness, friability, and depth, are of more importance than chemical ones, since the latter may be more easily changed through the use of fertilizers than the former.

A soil with a sandy foundation, particularly a sandy loam, is better suited for nursery operations than one with a clay or lime foundation (see Pl. I). The latter dries out and warms up slowly in the spring, delaying nursery operations and retarding the growth of the plants; it freezes and heaves much more decidedly than the former; it is more difficult to work in plowing, cultivating, and transplanting operations; the roots skin more when the trees are dug; it forms a hard surface and cracks upon drying; seedlings sometimes have difficulty in pushing through it; the development of the fine, lateral roots is not so good as in lighter soils; and weeds obtain a much firmer foothold. On the other hand, a soil extremely light, sandy, or loose should be avoided because of the rapidity with which it dries out, the too extensive and undesirable root development which it fosters, and the danger of general unthriftiness of the plants.

If the surface soil is a good, fairly moist, retentive, sandy loam, the deeper it is the better. Where it is deep there will be an abundant supply of fertility upon which to draw, the infertile subsoil will not be disturbed by plowing and mixed with the other soil, and the soil conditions will be ideal for the development of excellent stock. A very desirable combination is good, porous surface soil from 3 to 4 feet in depth, underlaid by a more retentive subsoil. Such a surface soil is of sufficient depth to allow the necessary drainage; and as moisture is needed it can be drawn from the retentive subsoil by capillarity. A subsoil of hardpan is to be avoided because it does not allow good drainage and the moisture retained may cause souring of the soil and excessive freezing and heaving.

### AMOUNT OF LAND AVAILABLE.

The future development of a nursery can seldom be forecasted. After the nursery is established the location, soil, or some other feature may be found to make it especially suitable for the growing of certain species of trees; the stock may have to be retained in the nursery longer than was anticipated; wider spacing may prove advisable; longer rotations of crops may become necessary; or a portion of the area may have to lie fallow longer than was expected. Any of these conditions will make extension of the nursery area desirable. A location should be chosen, therefore, where there is an additional contiguous area of good soil lying in such a position that the watering system can be readily extended to it.

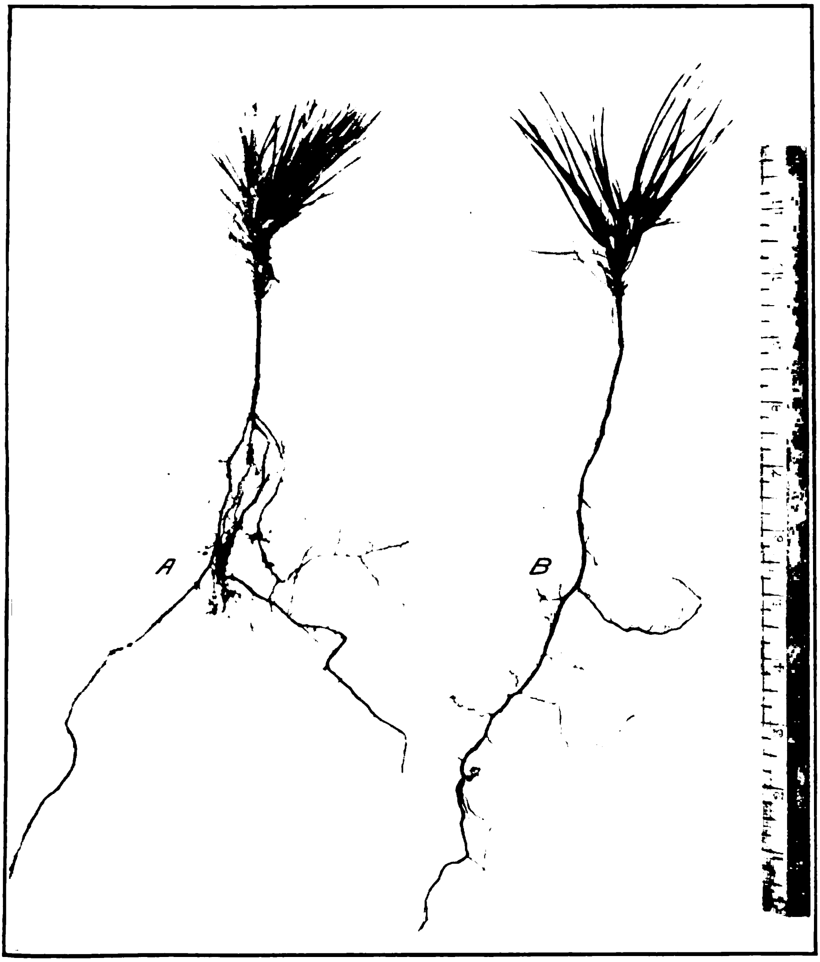
### SLOPE AND EXPOSURE OF SITE.

The nursery site should be as level as possible, because of the danger that the soil on a slope will wash during severe rains or artificial watering. Of course, grades can be lessened by terracing. This is expensive, however, and on terraced areas plowing and harrowing are carried on with difficulty, and protection ditches are almost indispensable. Under no circumstances should the slope exceed 5 per cent, and even such a slope is excessive where irrigation is to be practiced.

On slight slopes the exposure is of little import. There is but little difference in the temperature, frost danger, or length of growing season of the different aspects. On steeper slopes, north, northeast, and northwest aspects are more suitable for nursery purposes than south and west, because of the smaller range of temperature. Frost danger is greater on the south and west slopes than on the others, because the plants normally start growth sooner and continue it later. Alternate freezing and thawing, which causes heaving, is more decided on south and west slopes than on the other three. So-called frost holes, or depressions in which the air drainage is poor, and narrow valleys or canyons, should be avoided entirely because of frost danger. In general, a higher location should be given preference over a lower one.

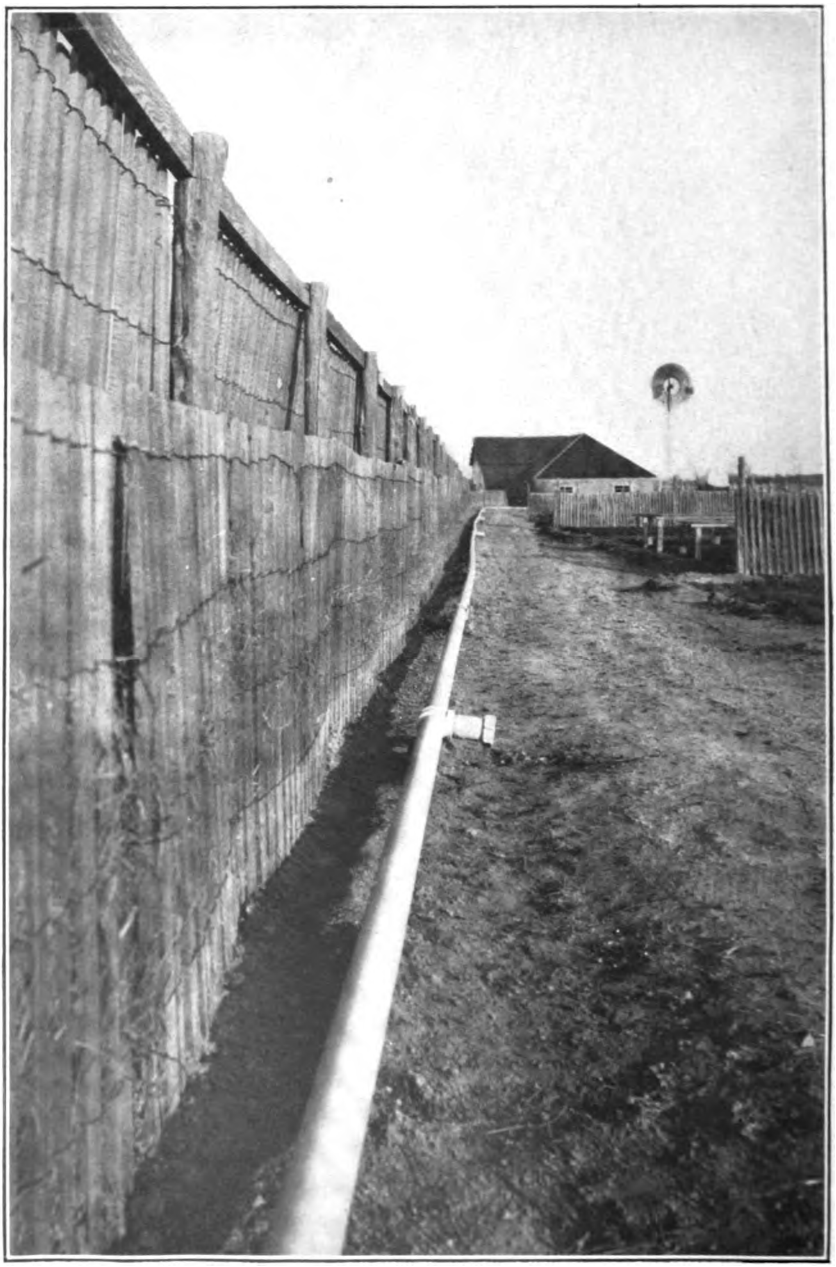
### ACCESSIBILITY.

The relative importance of accessibility to base of supplies and labor or to planting sites depends upon whether the nursery is large or small. If it is small and the amount of labor and supplies neces-



COMPARISON OF SEEDLING STOCK GROWN UNDER DIFFERENT SOIL CONDITIONS.

Note the difference in root development. *A*. *Pinus ponderosa* 2-0 Black Hills seed grown in light sandy soil. *B*. *Pinus ponderosa* 2-0 Black Hills seed grown in heavy clay soil.



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WATER-PIPE LINE 4 INCHES IN DIAMETER, FOR FLOODING TRANSPLANT BEDS, AND SLATTING FENCES USED FOR WINDBREAKS, BESSEY NURSERY.

sary is not great, it should be located as near the planting site as circumstances will permit. At a large permanent nursery, the initial as well as the regular yearly work necessitates the employment of a considerable number of laborers, the purchasing and hauling to the nursery of a large amount of material and supplies, and the hauling of the nursery stock to town for shipment. Accessibility to planting sites is not, accordingly, so important—though it is important—as location near a central shipping point where labor and supplies are readily available.

### SPECIES OF STOCK TO BE RAISED.

In fully equipped nurseries, moisture and temperature conditions can be so controlled that danger from drought, intense heat and cold, low humidity, and early or late frosts is partly eliminated; yet if possible, the climatic requirements of the principal species to be produced should be given consideration in choosing the site. If western yellow pine is to be the principal species, preference should be given to sites well within the low altitudes. If, on the other hand, Engelmann spruce or lodgepole pine will make up the greatest proportion of the nursery stock, preference should be given to the sites at higher altitudes. The natural common occurrence of a species in a certain region is an unfailing indication that both soil and climate are well adapted to its growth. Production will usually be attended by fewer difficulties and losses at nurseries located within such a region than elsewhere, although there have been some instances where this has not seemed entirely true. Furthermore, less watering and shading may be necessary and protection against frosts and winter killing uncalled for, so that it will be possible to produce a high grade of stock at less cost.

### NATURE OF THE SURROUNDINGS.

The surroundings have a minor effect upon nursery operations through their influence upon the weed problem, protection, shading, and watering. On old clearings, old burned-over areas, or abandoned fields, the conditions are particularly suited to the growth of weeds. At nurseries situated in such places it will usually be necessary to fight weeds continually. Such locations should be avoided if others fully as good in the more important considerations can be selected. There is the objection to having trees in the immediate vicinity of a nursery that they cause snowdrifts and retard melting of the snow in spring. It is possible also that they impede the circulation of air and thus subject the nursery stock to greater frost danger. Furthermore, excessive side shade from timber sometimes keeps a nursery too cold and damp for the best development of the stock.

In Europe it is considered advisable to take advantage of locations where shade and protection against wind are afforded by old stands on the south and west sides. For species especially susceptible to heat or frost, such as spruce and fir, this side protection is considered especially desirable. Where the planting stock is of light-loving species, such as pine and larch, there should not be enough shade to be harmful. The size of a large nursery will eliminate the possibility of side shade for all the beds; but this will not necessarily be a disadvantage, because, usually, shade will not be desirable for all the species grown. All the beds, however, may be protected from hot and cold winds, making less watering and possibly less artificial protection necessary.

### COVER OF THE SITE.

The growing cover of a site serves as a criterion of the quality of the soil, such as its fertility, acidity, or alkalinity, and normal moisture content. It also has an important bearing on the cost of putting the ground into condition for nursery purposes, the subsequent work which may be necessary, and the effect of the preliminary work upon the soil itself.

Dead and down logs and old stumps or a large amount of rock will necessitate expensive clearing operations. Where the stumps are large and numerous, as in Pacific coast Douglas fir cuttings, and the amount of down timber considerable, the cost of clearing and putting the ground into shape for nursery operations may amount to $200 or $300 per acre. This expense is not the only bad feature. Even after careful clearing and working up of the ground additional rocks, pieces of roots, bark, and twigs will be encountered for years to come. In removing rocks and stumps, moreover, the subsoil is thrown out on the surface, and being of inferior quality in most cases, gives rise to infertile patches throughout the nursery on which the growth of plants is poor. Besides when the stumps and logs are being burned the humus is also burned and the soil made poorer in quality. The inadvisability of choosing a rocky area or one covered with stumps is apparent unless other factors offset these disadvantages.

Too much emphasis, however, should not be laid upon the difference in the initial cost of soil preparation. Often the fact that timber has grown upon a site is a strong indication that after clearing the ground will be well suited for nursery purposes. While the cost of putting a treeless area into shape may be less, the site may not be so well suited for growing trees.

## CLIMATE.

If possible nurseries should be located where the climatic conditions are very similar to those of the planting sites. Nursery stock will then be in a dormant stage in the spring or fall when planting should be done. Where climatic conditions are not similar, it often happens that in the spring the nursery stock must either be shipped while the planting site is still covered with snow or else held at the nursery, where it is likely to start growth; or it may be that the planting site will be free of snow and in the best condition for planting before the plants can be removed from the frozen or snow-covered beds of the nursery. In the fall the plants may be still in an unhardened condition at the time when planting operations should be conducted.

Regions of excessive winter winds where a snow cover does not remain should be avoided because of the danger of winter killing unless artificial mulching is practiced. Mulching is expensive, and the mulch affords a refuge under which rodents may work and damage the stock.

Regions of excessive rainfall, particularly if the soil is a cold one, are not well suited for nursery purposes. In such regions weeds are more numerous than where the climate is drier, moss and algæ collect on the nursery beds, the stock is less sturdy, nursery operations are impeded, and the number of species which can be successfully grown is smaller.

## SIZE AND ARRANGEMENT OF NURSERY.

There are two general types of Forest Service nurseries: (1) The small nursery of a capacity ranging up to 200,000 plants annually, usually located at a ranger's headquarters and designed for the production of stock for planting only on the forest on which it is situated; and (2) the large nursery established to produce stock for planting a group of neighboring forests which have similar vegetal conditions.

The relative merits of small and large nurseries have not been finally determined; each possesses certain advantages over the other. Desirable sites of a suitable size for small nurseries are more plentiful than those for larger nurseries; the available water supply need not be so great; and permanent improvements in the nature of fences, water system, and buildings need not be so extensive. There is a decided advantage in growing plants near the areas where they are to be used; the stock is on hand when wanted; a part of the expense of packing and shipping is avoided, and retention by the roots of a part of the nursery soil, which would be shaken off in transportation, is permitted. Insect or fungous attacks in a small nursery can not, in the aggregate, produce such disastrous results as in a large one. Furthermore, the time suitable for field planting can be utilized more readily with locally grown stock. Trees raised in nurseries at a lower elevation, for example, may begin vegetation before conditions on the planting site permit setting them out, and the best time for planting a warm, early site may pass before stock can be furnished from a nursery in a colder situation. On the other hand, because of the closer and more efficient supervision in the large nurseries, as well as better facilities for tending the stock, a greater proportion of the plants normally survive to the age of field planting, and the better care given the stock results in its being more fully developed and, other conditions being equal, more able to succeed under field conditions. The concentration of the work at large nurseries makes for efficient management, good stock, and low cost of production.

A central nursery should have a capacity of at least a million plants. This is desirable as a matter of economy, for the larger the nursery the more opportunity there will be for intensified work, the systematizing of each operation, and regular supervision. By these means the cost per thousand plants may be reduced; three or four million seedlings can be grown at a lower cost per thousand than one or two million. A large capacity is desirable for two other reasons besides the economy that may be effected: It is an insurance against a shortage of plants due to unforeseen losses, and heavy grading is possible in well-stocked nurseries, so that in each case very nearly the class of stock required may be furnished.

The actual area of a nursery is determined by the output that is desired, the species, the area occupied by paths and roads, the spacings, the class of stock produced, and the practice followed in the rotation of crops. Possible rotation of crops being disregarded, the following table indicates the area, exclusive of paths and roads, necessary for the growing of 1,000,000 seedlings and transplants yearly.

TABLE 1.—*Seed-bed area*[1] *in square feet, necessary to produce 1,000,000 seedlings yearly.*

| Length of time in seed beds. | Number of seedlings per square foot. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 |
| | Area in square feet.[2] | | | | | | | | | | |
| 1 year | 20,000 | 13,333 | 10,000 | 8,000 | 6,667 | 5,714 | 5,000 | 4,444 | 4,000 | 3,636 | 3,333 |
| 2 years | 40,000 | 26,667 | 20,000 | 16,000 | 13,334 | 11,428 | 10,000 | 8,888 | 8,000 | 7,272 | 6,666 |
| 3 years | 60,000 | 40,000 | 30,000 | 24,000 | 20,000 | 17,142 | 15,000 | 13,332 | 12,000 | 10,908 | 10,000 |

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[1] Add 25 per cent in seed beds and from 10 to 20 per cent in transplant beds to allow for losses.

[2] 1 acre=43,560 square feet.

TABLE 2.—*Area*[1] *of transplant beds, in square feet, necessary to produce 1,000,000 transplants yearly.*

| Length of time in transplant beds. | Spacings, in inches, in transplant beds. | | | |
|---|---|---|---|---|
| | 1 by 5. | 1 by 6. | 1 by 8. | 3 by 4. |
| | Area in square feet.[2] | | | |
| 1 year | 34,722 | 41,666 | 55,555 | 83,333 |
| 2 years | 69,444 | 83,332 | 111,110 | 166,667 |

[1] Add 25 per cent in seed beds and from 10 to 20 per cent in transplant beds to allow for losses.
[2] 1 acre=43,560 square feet.

Because of differences in topography, in the characteristics of the soil, and possibly in the requirements of the species, the form of a nursery will vary as the location varies. Generally speaking, an area either square or rectangular, with the two adjoining sides not differing much in length, is the best form. The topography of the area often makes it impossible to lay out a nursery according to a preconceived plan. The necessity of following the base of a hill or avoiding rocky patches of ground may make regularity of outline inadvisable. The nursery should not be made up of a number of small individual areas. They may not admit of plowing and cultivating and may necessitate preparation by hand, a slow and expensive operation. Two or three larger areas widely separated do not make a good nursery because of the time lost in passing from one section to the other.

If uniform soil conditions exist throughout the nursery, there need be little choice as to the location of seed and transplant beds, except as a matter of convenience. Where uniformity does not exist, it is advisable to locate the seed beds in the portion having the better soil. Seedlings come up in close stands in the seed beds, so that they make greater demands upon the soil and are more subject to ill effects from poor soil than transplants, which have better conditions of growth. Where differences in soil, protection, or other conditions exist in the nursery area, it is also desirable to arrange the beds so that the hardiest species will occupy the most trying situations. Thus western yellow pine can be grown to better advantage in stony portions or those most likely to dry out rapidly than can spruce, and spruce and fir should be grown where they would have the advantage of any natural shade. This phase of nursery practice is not of great importance, however, since the conditions can be so changed artificially that any of the species can be made to thrive in any part of the nursery. Where it is necessary to shade either the seedlings or transplants, the beds should have their long axes east and west.

The water system, after it is established, will determine to some extent the arrangement of the beds. A row of hydrants will fix the location of a path, and to facilitate watering at least the transplant beds should be laid out with their long axes at right angles to this path or row.

## OUTFIT.

### WATER SYSTEMS.

The initial cost of a water system is high, and once a system is installed it can be changed only with considerable difficulty and expense. A satisfactory system will save many hitches and delays and in the end will effect great economy. It is desirable, therefore, to plan carefully before its installation and to have in mind its really essential and most desirable features. These will be enumerated under the discussion of the different kinds of systems. There are two principal types of systems in use in nursery operations: (1) The irrigation system, and (2) the sprinkling system.

### IRRIGATION SYSTEM.

In the irrigation system the water is brought to the nursery area either in a ditch or flume which taps a supply at an elevation somewhat above that of the nursery, or it may be pumped from a lower level to that of the nursery. It is then distributed to the plants either by means of numerous small ditches from 2 to 3 feet apart having so slight a gradient that the water flows very slowly, or by flooding entire beds. When water is diverted from a stream desirable features of an irrigation system are a good, substantial dam at the point of diversion of the water, a head gate which permits perfect control of the water entering the ditch, and a clay-lined ditch or a flume to convey the water to the nursery. A flume or water pipe is somewhat preferable to an open ditch. The gradient of the main ditch or flume will depend upon the velocity desired and the cross-sectional area of the channel. At the Savenac Nursery the main ditch, which is slightly over a mile in length, has a fall of 6 feet. The gradient of the small ditches which convey the water to the plants throughout the nursery should not, in heavy soils, exceed 1½ inches, or, in light, porous soils, 3 inches per 100 feet.

When water is pumped from a lower level directly to the nursery for irrigation purposes, the prime essential in addition to that of gradient is that there be pumps of sufficient capacity to furnish all the water necessary while the operation is in progress. At the Bessey Nursery three 5-horsepower gasoline engines and centrifugal pumps are used to pump water from the river into a 4-inch main pipe line which runs along one edge of the nursery. (See Pl. II.) From this pipe it is distributed to the beds through 6-inch canvas hose, flooding being practiced for transplant beds and for the seed beds after germination is completed.

### SPRINKLING SYSTEM.

In the sprinkling system the water is conveyed to and through the nursery by a system of pipes and applied to the plants ordinarily by the use of garden sprinklers. Where it is practicable, a gravity pipe-line sprinkling system in which water is diverted from a spring or stream at a higher elevation and thence conveyed directly to the nursery is the best type because it is the simplest. A system with a tank or reservoir above the level of the nursery to which water is pumped and then piped to the nursery may in some cases be the most practicable one. A tank or reservoir may sometimes be necessary, even with a gravity system, to provide for storage of water to meet the needs of the nursery when heavy watering is practiced.

In planning a sprinkling system the length of hose to be used should first be decided. The most convenient length is 50 feet. Greater lengths are cumbersome; shorter lengths necessitate a too frequent change of faucets. As a hose should reach half way between parallel lines of pipes, it follows that adjacent pipe lines should not be farther apart than 100 feet. Given two faucets 100 feet apart, it is clear that a 50-foot hose will convey water in a line with them over a distance of at least 190 feet. This allows only 45 feet for the length of the hose, the assumption being that a portion of its length will be taken up by curves at the faucet and nozzle. Keeping on a path, a man, hose in hand, can conveniently water a strip only about 15 feet wide on either side of it. This indicates that the paths from which the watering is to be done should be 30 feet apart and that there should be a faucet at each path. Thus the sections of beds should be 30 feet wide throughout and of any desired length up to 100 feet. For a sprinkling system of watering, this is believed to be a very economical arrangement of pipe lines and faucets. If a shorter hose were used it would be necessary to have the main pipe lines closer, necessitating more pipe and more labor for installation. The use of a longer hose would mean less pipe, but much additional time and labor in handling the hose. The increased weight of longer hose is not of particular significance, but the care necessary to prevent its dragging across the beds and bending and breaking the plants is much greater in long than in short lengths.

From each faucet of a system so installed an area of 3,000 square feet can be watered by means of a nozzle. If lawn sprinklers are used the spacing of the faucets on each pipe line should be regulated by the distance to which the spray can be thrown when several sprinklers are in use. Twice this distance will determine the spacing. Thus if the spray can be thrown in a radius of 10 feet the faucets should be 20 feet apart.

The pipe should be sunk deep enough to allow the use of plow and harrow in preparing the ground; and where there is need for water all winter, the system should be buried deep enough to avoid the danger of freezing.

The longer the pipes the smaller their diameter, and the less the head of water the greater is the decrease in flow through friction. It follows that to obtain the same flow per unit of time the head of water must be greater when small than when large pipes are used, and that with a given head and quantity the greater volume of water will be available for use if it is conducted to and through a nursery in large pipes. It is often difficult to control the length of the pipes and the head of water. The size of the pipe used, however, is entirely within control. In order to secure sufficient pressure to run 10 or 12 sprinklers at the same time there should be a head of water not less than 50 feet; the main pipe should be 3 or 4 inches in diameter (the latter is preferable); and the laterals and standpipes should be 1½ or 2 inches in diameter. One system which embodies these features has over 4,000 feet of main-line pipe, but at its lower end it carries 75 gallons of water per minute.

To facilitate its cleaning out, a water reservoir should have an outlet besides that of the distributing pipe line. To prevent sand or gravel from getting into the system and clogging nozzles or sprinklers, the pipe at the intake should be covered with both a coarse and a fine screen.

There should be one gate valve next to the reservoir, one on the main pipe just before it reaches the nursery area, and one at the junction of each lateral with the main pipe. The pipe line should have union connections at intervals of approximately 100 feet and at the junction of branches. These will make it unnecessary to dig up the entire line when there is a part to be mended. There should be a plug or preferably a gate valve at the lower end of the main and of each branch of the pipe line. These will permit the washing out of the pipes in case they become clogged or obstructed, and also their draining for the winter. All of the unions and any of the other important parts of the underground pipes should be clearly marked on the ground itself in some manner, such as by boxed openings or slightly projecting stakes. Finally a very careful diagram of the system, on which all of its parts are clearly indicated, should be drawn to scale. A system embodying these desirable features is shown in figure 1.

*Cost of pipe.*—While the costs of pipe vary, some of the prices paid at Forest Service nurseries are cited, simply to show the relative value of different types:

| | Cents per foot. |
|---|---|
| 6-inch Douglas fir wooden pipe[1] | 17¼ |
| 4-inch Douglas fir wooden pipe | 13½ |
| 4-inch black iron pipe | 43½ |
| 2½-inch galvanized-iron pipe | 25 |
| 2-inch galvanized-iron pipe | 18 |
| 1¼-inch galvanized-iron pipe | 12 |
| 1-inch galvanized-iron pipe | 8 |

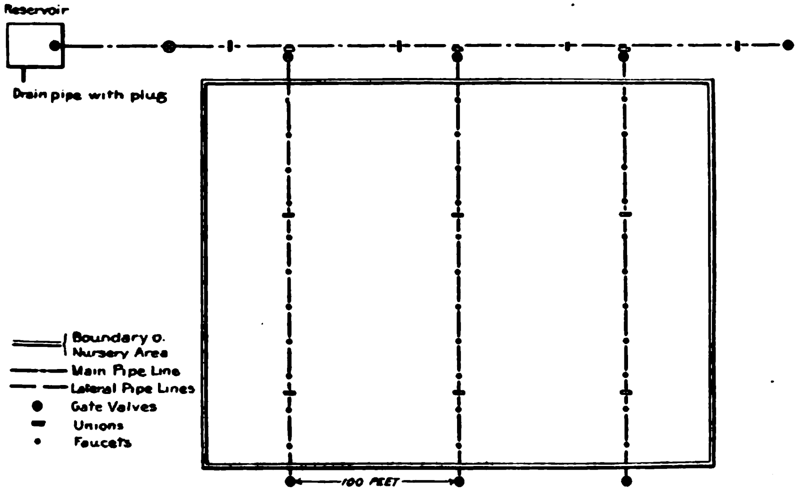

FIG. 1.—Diagram of a water system.

### COMPARATIVE MERITS OF IRRIGATION AND SPRINKLING SYSTEMS.

In general, irrigation is not so satisfactory as a piping system. It has some commendable points and others which are objectionable. It does not require so large an initial outlay as a sprinkling system; there need be very little head to the flow of water; in subirrigation by ditches heavy soils do not tend to bake so much as when sprinkled; possibly a greater area can be covered per day than by sprinkling, and the water which comes in open ditches usually is warmer than that coming through pipes, which is a desirable feature. On the other hand, to irrigate effectively there must be very little slope to the land and the area must be very evenly graded; ditch irrigation necessitates frequent paths, and consequently a much larger area for the production of stock, with all that it entails in preparation, fertilization, weeding, and cultivation; the main ditch may silt up and have to be dug out each spring and the laterals have to be entirely reconstructed each time the area is replowed; it takes a more experienced man to water by irrigation than by sprinkling; a considerable number of plants are covered in digging out and filling up a ditch to divert the water from one ditch to another; transplants can not very readily be watered immediately after being set out; all plants are not watered evenly; baking is worse when flooding is practiced on clay soils than under any other system; and it requires more water for each operation than does sprinkling.

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[1] Douglas fir wooden pipe has given excellent satisfaction where used. Galvanized-iron pipe wears better than black iron pipe.

### INCLOSURE FOR NURSERY AREA.

At every permanent nursery a good fence is needed, and all nurseries subject to damage through grazing by domestic stock or by deer must be adequately fenced against such animals. Where rabbits abound it will often be desirable to protect the nursery against them by meshed wire screen at the base of the fence or by a woven wire fence whose lower mesh is small enough to exclude them.

If a nursery is subjected to the action of heavy winds which bend, whip, or break the plants or shift a light soil so as to cover a portion of them, or dry out the soil, a windbreak is desirable. A slat fence 5 or 6 feet high will afford some protection. A very effective windbreak is made by nailing parallel rows of slatting on both sides of a row of posts and stuffing the space between with hay. Living windbreaks of trees or shrubs also afford protection and where needed should be grown. The trees or shrubs chosen for the purpose should be those of a compact, bushy habit which are known to be hardy in the locality. They should be planted from 25 to 50 feet from the nursery area. If immediately adjacent, they do considerable damage to the nursery stock growing within their root zone.

### NURSERY BUILDINGS.

At large nurseries there will generally be needed several nursery buildings, a house and woodshed for the man in charge, a barn, a packing shed, and a storehouse. The storehouse will serve as a storage place for seed supplies, tools, stakes, hose, lath shade frames, seed-bed frames of the knock-down type, and any other equipment. It should be located as near the nursery as possible. The packing shed should be partly open to the south and should be supplied with packing-box material, moss, burlap, nails, cord, labels, and paint.

At nurseries so far removed from town that it will be necessary at times to feed and house a working crew, a cook house and bunk house will be necessary. The bunk house should be furnished with a heating stove and the cook house with a large cooking range, a complete set of cooking utensils and dishes, good working benches, a sink and drain, running water if possible, a hot-water barrel, shelves, and a long dining table with benches. A small storeroom for supplies and a bedroom for the cook and cookee should be partitioned off.

### NURSERY EQUIPMENT.

Considerable equipment is necessary in a nursery. The loss of time and increase in labor and trouble caused by insufficient equipment will ordinarily amount in a short time to more than the cost of an adequate supply. The equipment is not the same in all nurseries; but that generally needed and its current cost in 1913 is indicated below:

| Equipment. | Cost. |
|---|---|
| Team | $350-$400 |
| Box wagon | 75- 100 |
| Plow, 14-inch | 16.50 |
| Harrow | 18.00 |
| Axes with handles: | |
| Single bit | 1.75 |
| Double bit | 2.00 |
| Shovels | 1.25 |
| Spades | 1.25 |
| Rakes | .75 |
| Mattocks with handles | 1.25 |
| Picks with handles | 1.25 |
| Sledge No. 6 | 1.10 |
| Post-hole digger | 1.75 |
| Crowbar, per pound | .08 |
| Forge | 10.00 |
| Anvil, per pound | .13 |
| Tools for forge, per set | 12.00 |
| Hoes | .75 |
| Pipe tools: | |
| Threader and dies for 1-inch and 2-inch pipe | 7.50 |
| Pipe vise | 2.25 |
| Stillson wrenches, 14 -inch | .65 |
| Stillson wrenches, 18-inch | .90 |
| Hammer | .75 |
| Carpenter's saw | 2.00 |
| Steel square | 1.50 |
| Chisels | .50-1.50 |
| Brace | 1.25 |
| Set of bits for brace | 4.50 |
| Bench screw for vise | .75 |
| Hose, per linear foot | .12 |
| Mole trap | 1.25 |
| Gopher trap | 1.25 |
| Mouse trap | .05 |
| Nails, per pound | .05 |
| Screws (price varies) | |
| Planting boards (price varies) | .50-2.50 |
| Heavy flax twine, per pound | .35 |
| Wheelbarrow (steel) | 7.50 |
| Scale for weighing seed | 10.00 |

In addition, it is always well to have on hand a little lumber—dimension stuff, planks, and boards.

## NURSERY OPERATIONS.

### NURSERY SUPERVISION.

The measure of success in nursery practice is the character of the stock produced and its cost. The various operations should therefore be under the supervision of an efficient executive or foreman, one who is thoroughly practical, a close observer, constantly alert to improve methods in the ordinary routine, and fully alive to the desirability of reducing costs of operation and overhead charges. It is desirable that he have a knowledge of plant physiology and pathology, for this will enable him to note quickly imperfections or disease in his stock and to seek methods for improving its quality or health.

### INITIAL PREPARATION OF NURSERY SITE.

On a site which has already been cleared or is free of all stumps, logs, and woody growth, the first step in preparing the ground is to remove the litter, rocks, and pieces of roots. The surface soil should be thoroughly hand raked and rubbish carted away; the area should then be plowed and harrowed very thoroughly. Where there is a grass cover it should be scraped off close and burnt to ashes after the sod is thoroughly dried; or better, it may be plowed under and the area devoted to field crops for a year or two until the sod is thoroughly decomposed. Piles of brush should not be burned on the nursery area because deterioration of the soil results.

Experience has proved that plowing and replowing and harrowing and reharrowing, amply pay for themselves in the resulting condition of the area. Rocks, roots, and trash which would interfere with the nursery operations are not only brought to the surface and removed, but hollows are filled in and elevations cut down until the whole surface is brought to an even grade. The initial plowing and harrowing must be more intensive than those of after years because of the greater amount of rubbish present and the roughness of the land. Heavy soils, fall plowed and left rough, are much mellowed and improved by the action of the frost and are in a better state to absorb and retain the winter moisture. Unless replowed in the spring, however, they are packed and hard to work. Spring plowing and harrowing puts a soil in excellent condition for working; but after transplanting operations are finished the soil may settle and leave the plants sticking too high out of the ground. The combination of fall plowing with cross plowing and harrowing in the spring is undoubtedly best, provided the soil can be watered and settled somewhat before transplanting begins.

The seed-bed area should be further prepared with a shovel or garden fork, the lumps of earth mashed, and then finely pulverized by raking. In either plowing or spading the soil should, if possible, be stirred to a depth of a foot. Very shallow cultivation may result in shallow root development, heaving, and poor plant growth through drying out of the soil. Deep cultivation involves the risk of bringing to the surface the poorer, less fertile subsoil, in which plants do not develop properly.

### PREPARATION OF SEED BEDS.

Where damage from rodents or birds need not be guarded against the seed beds may be of any desired size. They should be staked off uniformly and with mathematical precision. This will make calculations easy and will make possible the employment of uniform methods in subsequent work. A 4-foot width facilitates sowing, covering, and weeding operations. Forty inches has been found to be a desirable width where burlap is used as a cover. Where damage from rodents or birds is possible small beds 4 by 12 feet are desirable, because they are easily protected by the use of the screened frames, to be discussed later.

To promote capillary action and avoid uneven settling of the soil, particularly where the soil is light and sandy, the beds should either be rolled with a heavy hand roller or thoroughly watered before the final leveling. The leveling and smoothing of the surface is done with a rake and should be thorough. It will help in securing an even covering of the seed and uniform germination, for an irregular surface is often responsible for seedlings appearing thickly in one spot and thinly in another.

At one of the California nurseries a special method of leveling has been used. A frame 4 by 12 feet, inside dimensions, is constructed of 1 by 4 inch material, the boards resting on edge. This is sunk about 1 inch into the beds that have been spaded and raked. A section 3 inches wide by 6 inches long is cut out of the lower edge of each end of a board 1 inch by 4 inches by 5 feet, which results in the shape shown in figure 2. The portion of the board which is 4 feet long and 3 inches deep is intended to fit within the 4-foot frame, the 6-inch ends resting upon the sides of the frame and serving as handles. The appearance of the frame and board in operation is shown in figure 2. The board, which is called the "planing board," is drawn the length of the bed with the projecting inner 4-foot portion sweeping over the loose soil. As the board is drawn along it may be necessary to fill in with soil any low places in the bed in front of it. The surface of a bed thus prepared will be smooth and ready for sowing.

A slight modification of the apparatus appears to be more practical. The frame need not be sunk into the bed, but may be rested on the surface of the soil. The projecting portion of the planing board will then have to be as deep as the frame itself. Three-inch material, stiff enough to retain its shape, is wide enough for the construction of the frames. At the Wind River Nursery, where this system is follcwed, the lower sill of the shade frame is used instead of a special frame.

On first-class nursery situations the drainage of the seed beds will not need consideration. If the drainage is not good on account of the situation or the soil, it should be improved by raising the beds slightly above the surrounding level and the center of each bed slightly above its edges. Ordinarily the beds can be raised sufficiently by shoveling out the paths from 2 to 4 inches deep. An ample edge should be allowed for the frames and for washing by rain. If the soil is very loose, it may be necessary to protect the edges of the beds by a board frame sunk in the ground.

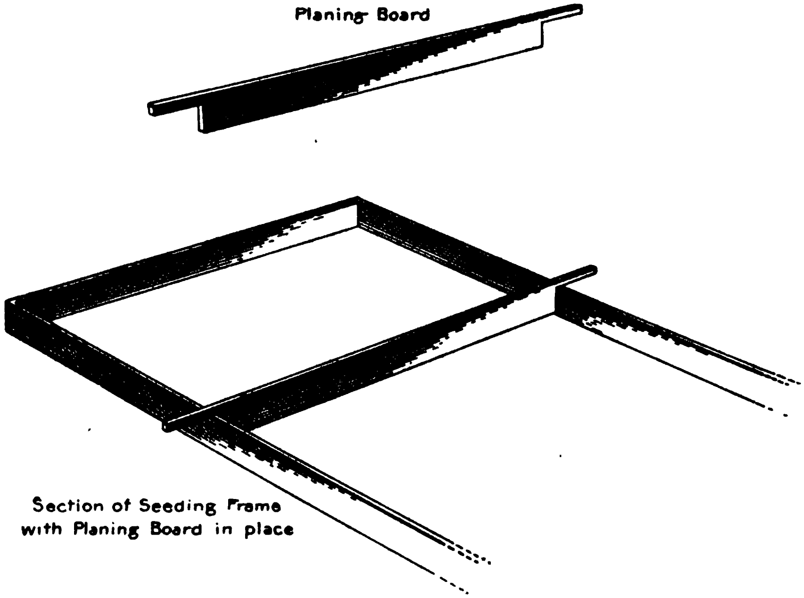


FIG. 2.—Seed-bed equipment.

The cost of preparing seed beds, including plowing, harrowing, spading, and raking, has been $0.0027 per square foot at the Boulder Nursery and $0.00416 at the Wind River Nursery.

### SOWING OF SEED.

Seed sowing is considered by some as the most important single nursery operation. Sowing to secure the desired number of trees per square foot requires considerable knowledge, skill, and care. Hence, this is work that capable nurserymen handle themselves or supervise very closely.

The following points are of especial importance. All seed used in a nursery should be fresh and clean. Fresh seed germinates more vigorously and is less liable to rot than old seed, and it is not so likely to produce distorted, weak seedlings. Seed from local collecting is best because the seedlings produced are best adapted to the soil and moisture conditions and to the length of the growing season at the nursery. When feasible the seed should be graded so as to eliminate the weak seed in the beginning and prevent the production of stock which is undesirable and will have to be discarded later on. Other things considered, the larger seeded forms of a species are to be preferred because they produce larger plants in the same length of time than the smaller seeded varieties.

In no case should seed be used whose germination per cent is less than the average for the best fresh seed of the species. Germination tests should be made, and the seed which is found unsuitable rejected. The use of seed whose quality is not known may result in very thin stands of seedlings and thus upset nursery and planting plans for a year or two. When regular germination tests have not been conducted, some knowledge of the quality of the seed may be obtained by cutting open 200 or more and noting the condition of the kernel or meat. If the kernel is plump and full and of a good cream or white color the seed is probably good. This test is not wholly a reliable or satisfactory one, however, since it usually gives higher percentages of good seed than are obtained when regular germination-test methods are employed.

Seed which will germinate at the rate indicated in the following table will generally prove satisfactory for nursery purposes. The figures were obtained through actual tests of 200 seeds of each species, sown in small flats filled with sand or soil and exposed to a greenhouse winter and spring temperature of from 60° to 80° F. The figure given under 100 days is not necessarily the final germination per cent of the species; but the percentage shown for each species listed is a very good one for a test covering that period of time.

*Results of germination tests.*

| Species. | Germination per cent. | | | |
|---|---|---|---|---|
| | In 20 days. | In 30 days. | In 60 days. | In 100 days. |
| Abies concolor | ........ | 2 | 7 | 10 |
| Cupressus arizonica | 25 | 33.5 | ........ | ........ |
| Larix occidentalis | 25 | 30 | 40 | ........ |
| Libocedrus decurrens | 44 | 54 | 61 | 64 |
| Picea engelmanni | 70-86 | ........ | ........ | ........ |
| Pinus contorta | 60-70 | 70-85 | ........ | ........ |
| Pinus jeffreyi | 24-30 | 40-45 | 70-75 | ........ |
| Pinus lambertiana | 5-10 | 21-33 | 47-59 | 68-70 |
| Pinus monticola | 2-2.5 | 3- 4 | 12-14 | 42-45 |
| Pinus ponderosa: | | | | |
| Black Hills | 60-65 | ........ | ........ | ........ |
| Colorado | 76-90 | ........ | ........ | ........ |
| Arizona | 80 | ........ | ........ | ........ |
| Montana | 71 | ........ | ........ | ........ |
| Idaho | 41-46.5 | 56-62.5 | 75.5-80 | ........ |
| California | 30-36 | 36.5-42.5 | 69.5 | 86.5 |
| Pseudotsuga taxifolia: | | | | |
| Rocky Mountain form | 70-74 | ........ | ........ | ........ |
| Idaho | 21 | 43.5 | 61-69 | ........ |
| Coast form | 3 | 10 | 46 | 63 |
| Sequoia washingtoniana | ........ | 30-38 | ........ | ........ |
| Thuja plicata | 47 | ........ | ........ | ........ |

### METHODS OF SOWING.

Whether sowing shall be broadcast, in drills, or in flats will be governed largely by local conditions. Each method has advantages under certain conditions.

In drill-sown beds cultivation and weeding between the rows by means of small hand tools is possible, and root pruning can be practiced. Where cultivation is practiced there is less need of watering, and the soil is better aerated and is kept warmer and in better tilth. Even stands are more easily secured by an inexperienced man in drill sown than in broadcasted beds; seedlings can be more easily dug and with less damage to the roots, particularly in heavy soils, and in some cases winter damage from snow (as with Douglas fir at the Cottonwood Nursery) and heaving are less serious. Damping-off can be more readily controlled by cultivation when the beds are drill sown than when they are broadcasted, provided the conditions are such that cultivation is effective against the disease. Such cultivation, however, is seldom effective. On the other hand, the drill-sown seed in germinating may break the soil and leave an open ditch in line with the drills, thus exposing the seed which have not yet germinated. Where damping-off is prevalent this partly open ditch forms an ideal moist chamber for the development and spread of the fungus along the whole row. At the Priest River Experiment Station damping-off has been more serious in drill-sown western yellow-pine beds than in broadcasted. Drill sowing is not well adapted to the sowing of seed with a low germination per cent, because the drills must be made deep and the seed sown very thick in the row, with the result that a portion of them do not come in contact with the soil, and the bottom seed are covered so deeply that upon sprouting they are unable to push their way through the covering above them.

In broadcasted beds cultivation is not possible and weeding must be done by hand, but if the beds are fully stocked the plants will shade the ground completely, decreasing evaporation and killing out the weeds, so that there is less need of these operations. A greater number of good seedlings can be grown per square foot in broadcasted beds; if necessary an area can be resown without disturbing the original stand; and the plants are less crowded and in general reach better development than in drill-sown beds. Broadcasting permits the necessary heavy sowing and uniform covering of seed having a low germination per cent.

In general it seems that in heavy soils or at nurseries where the water supply is deficient, either of which makes cultivation desirable, or where root pruning is to be practiced drill sowing is preferable. Where cultivation appears unnecessary and the water supply is sufficient, or where it is desirable to effect an economy in space, as under high shade frames, broadcasting is preferable. In Forest Service nurseries broadcasting is coming more and more into favor.

*Sowing in drills.*—In the drill method the seed are distributed in drills from 3 to 6 inches apart and from one-fourth to one-half inch deep by means of a hand seed drill, or a seeding board, or by hand. If a seed drill is used, it has to be regulated by trial to sow the proper number of seed per linear foot. After the drill is regulated the hopper is filled with seed and the drill is pushed ahead in a straight line. At the Cottonwood and Pilgrim Creek Nurseries drills have proved twice as rapid as broadcasting. However, there are some drawbacks—resinous seed stick and do not feed well; the seed must be very clean; it is difficult to regulate the drills so that they will distribute the seed evenly, especially small seed; and the drills are not so well suited for sowing across the beds as lengthwise.

For drill sowing across the beds a marker, hinged seeding board, and a seed trough (see fig. 3) have proved highly efficient. The marker consists of a plank 4 feet long, 15 inches wide, and 1½ inches thick, with two handles projecting beyond each end, and with triangular strips of wood from one-half inch to 1 inch thick on a side and 4 feet long, nailed longitudinally and parallel, from 3 to 6 inches apart, on its under side. By pressing these triangular strips or cleats into the soft earth of the prepared seed bed perfect V-shaped depressions can be made of the depth desired. Two men can mark from 100 to 200, 4 by 12 foot beds per day with this board, depending upon the depth desired and the condition of the soil.

The seeding board consists of two strips of board 4½ feet long, 3 inches wide, and three-fourths inch in thickness (narrow bevel siding is sometimes used), joined edge to edge by a small hinge at each end. The adjoining edges of the boards for a distance of 4 feet (the width of the seed beds) are beveled on the top side between the hinges, one edge much more than the other, so that a shoulder is formed on which seed uniformly distributed will remain when the board is dipped into the trough partly filled with seed, then tipped each way so that all superfluous ones will fall back into the trough. By varying the depth of the groove and the width of the shoulder on the adjoining side the board can be made to sow any quantity desired. One of the outer edges of the board is beveled far back on the under side so as to offer no obstruction when the seed is dipped. Two men operate it, one at each side of the bed. The board is dipped with a swinging motion into the trough and then lowered and held close over the drill to be seeded; the hinges are bent upward, and the seeds fall into the drill.

The seeding trough is 8 inches deep, rounded slightly on the bottom and up one side, from 10 to 14 inches wide, and 5 feet long. It is mounted on legs, raising it from 16 to 24 inches above the ground. The trough is set to straddle a seed bed in which drills have been

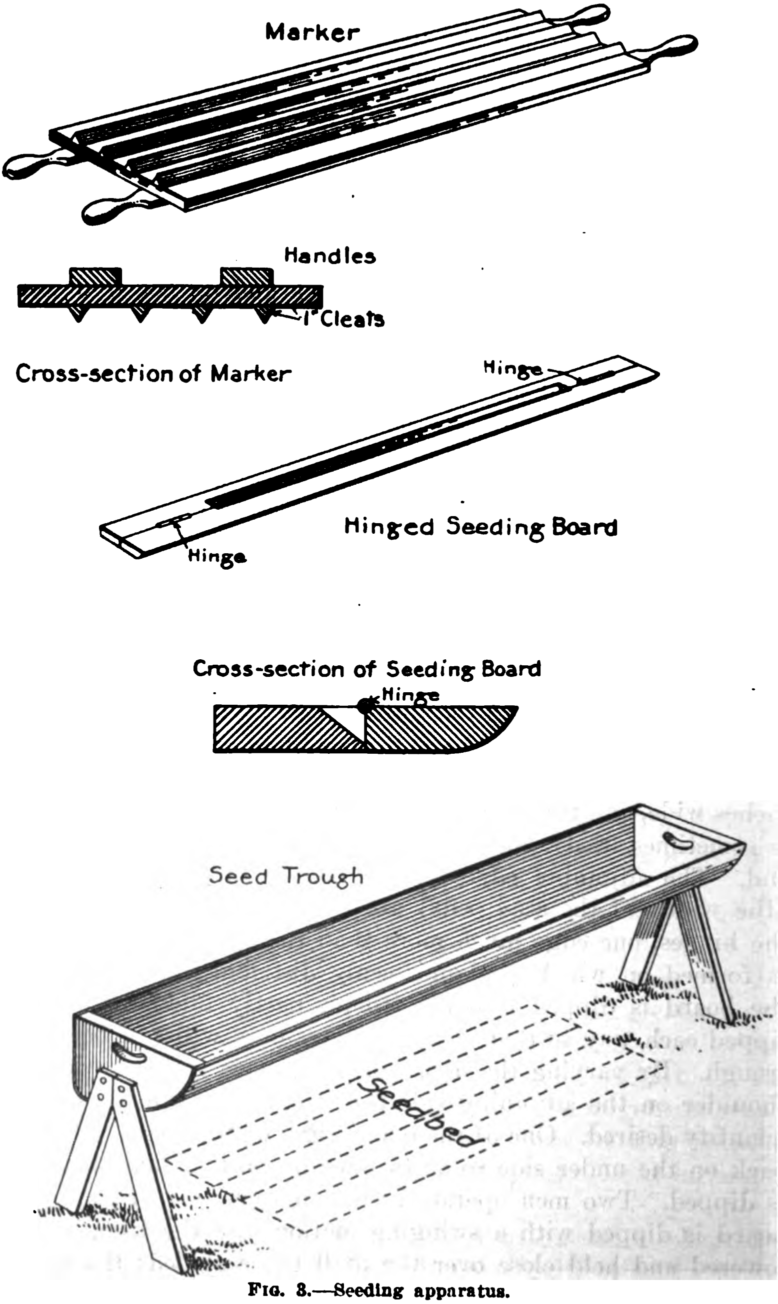


FIG. 3.—Seeding apparatus.

marked. By this method two men can easily sow per day from 30 to 40, 4 by 12 foot beds, of 48 drills each, and as many as 60 have been sown. The seed is covered by another man. Working too rapidly should not be allowed, since speed induces carelessness with the average workman. The nurseryman himself should, if possible, be one of the crew to manipulate the board, or he should select very reliable men for the operation.

Drills are also made with a concrete roller fitted with parallel, evenly spaced cleats extending its entire length (Pl. III, fig. 2) and with a large, heavy wooden rake whose teeth are spaced at the right interval; and seed sowing is conducted by hand, with shotgun shell, or with a tin can with a hole punched in the bottom. None of these methods, however, are so rapid nor any more efficient than the first described.

*Broadcast sowing.*—In broadcasting, seed is scattered by hand over the prepared beds. The total amount is not entirely distributed the first time; a portion is reserved, so that the sower may again cover the area and scatter it where there is a sparse distribution. Proficiency in broadcast sowing is obtained only after considerable experience, and even stands of seedlings are not so readily secured by an inexperienced man as in drill sowing. When the sower is experienced this method is rapid, one man when not covering the seed being able to sow an area of from 4,000 to 9,000 square feet in a day. After sowing the seed should be pressed into the soil by means of a wide, flat board or by a light roller. The board or roller should be dry, or the seed will stick to it.

*Sowing in flats and pots.*—For southern California, where the climatic conditions are especially trying on young planted trees, some transplant stock is produced in individual paper pots. The seed are sown in flats, and the seedlings transplanted into the pots, which are later set out in the field.

Several small holes are bored through the bottom of the flats, one-half inch of small gravel is put in to allow for drainage, and then 4 or 5 inches of good loamy soil. This is packed in, the surface is smoothed, and the seed is sown and covered.

Sowing in flats has three advantages—very good drainage can be provided for the seedlings, the depth of the covering of the seed can be well regulated, and transplating is easier. On the other hand, it is more expensive than raising stock in seed beds, because of the added cost of flats, mixing of the soil, and more intensive care. It has also been found with conifers that the stock produced has a very inferior unbranched root system.

The sowing of conifers directly in the pots has also been tried. This scheme appears to have little to commend it. It is expensive, the seedlings in a large number of pots are likely to die, necessitating their resowing, and a thrifty class of stock is not produced in most instances.

### SEASON FOR SOWING.

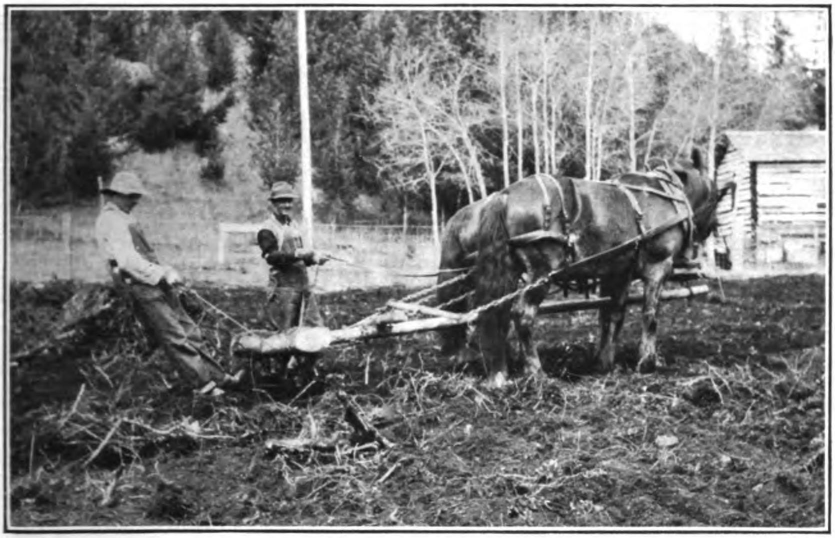
The season for sowing is largely determined by the species raised, by local climatic conditions, and by experience in nursery practice. If the seed is of a species which germinates slowly, such as western white pine, sugar pine, the Pacific coast form of Douglas fir, or incense cedar, heavier and better developed stands of seedlings are usually secured by sowing in the fall than in the spring. Some seed, such as deodar cedar and the true firs rapidly lose their vitality. For these fall sowing immediately after their collection is also preferable. In most cases species whose seed germinate rapidly can very well be sown in the spring, so as not to be exposed over winter to damage from rodents or subject to the danger of extremely early germination and subsequent killing by late frosts. However, spring sowing, even of such species, is not always thought desirable. Damping-off is less severe, for instance, in fall-sown than in spring-sown beds of jack pine at the Bessey Nursery.

At the Pocatello Nursery it is thought best to sow in the late spring, because the weather is so cool during the spring that no advantage would be gained by fall or early spring sowing. In Arizona and New Mexico, where the spring of the year is very dry, some of the sowing is deferred until the near approach of the rainy season, which occurs in July and August. Seed sown in these States in the spring requires frequent watering after germination; those sown in the summer do not need artificial watering. Damping-off, however, is less severe there in spring-sown than in summer-sown beds.

Fall-sown seed have a long period in which to absorb moisture, and germinate rapidly upon the advent of warm spring weather. Watering of the seed beds to induce germination is usually unnecessary. Moreover, the stock from fall-sown seed is more likely to be fully hardened and able to withstand early fall frosts than that from spring sowing. Stock larger by from one-half inch to 2 inches can be produced in one year by fall than by spring sowing. The increased growth may mean the shortening by a year of the length of time necessary for growing stock to a size suitable for field planting, thus effecting an economy of space in the nursery and reducing the cost of the plants (Pls. IV, V, XV).

### AMOUNT OF SEED TO SOW.

The optimum number of seedlings per square foot in seed beds varies according to the species, the region (because of the longer growing season and greater development of the stock in some regions than in others), the manner of sowing (broadcasting or in



F-65923

FIG. 1.—CLEARING LAND FOR A NURSERY.

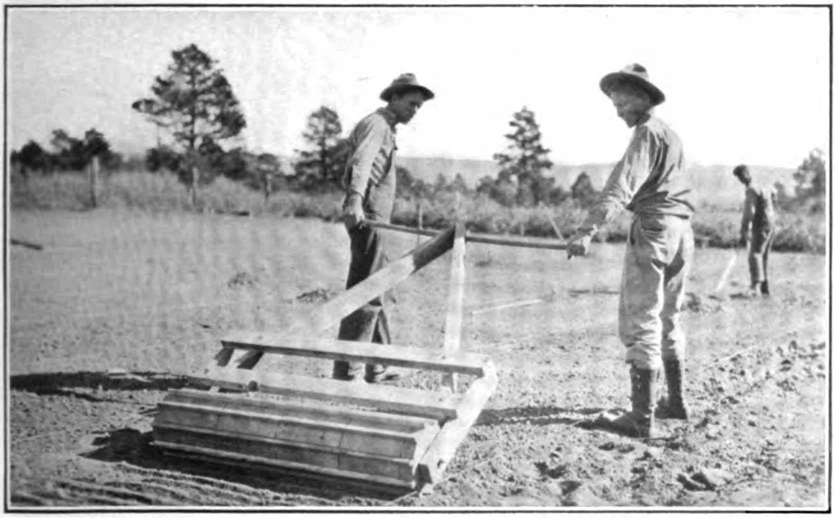


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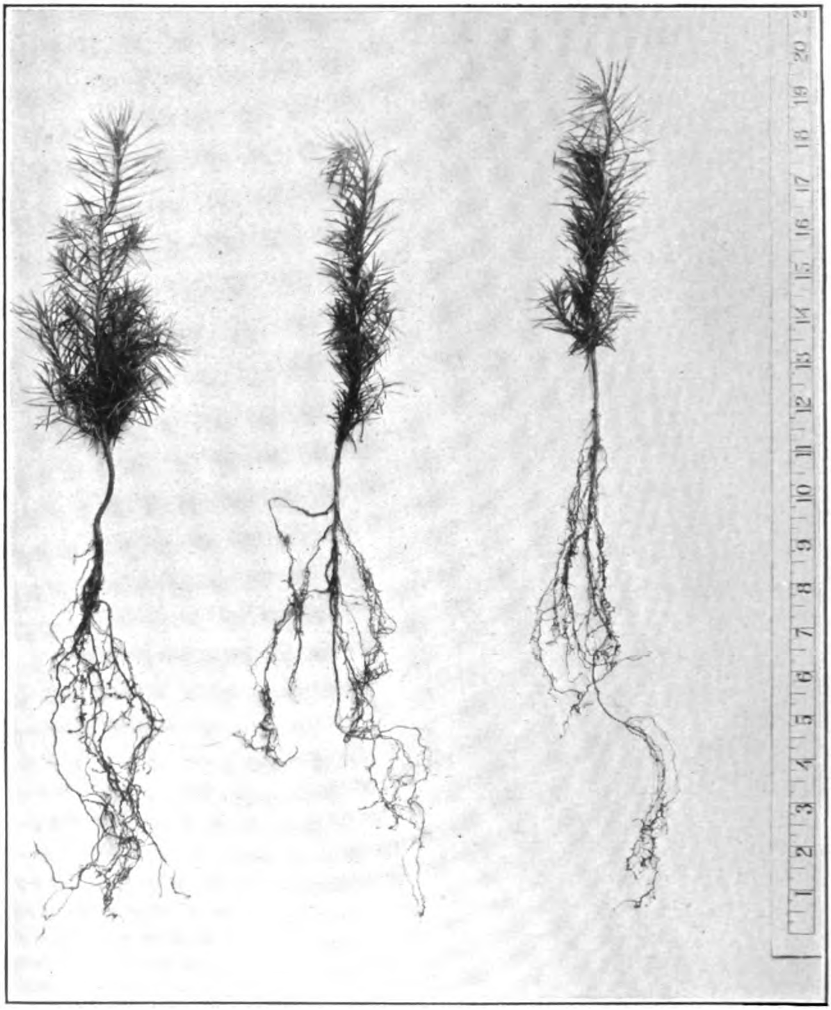
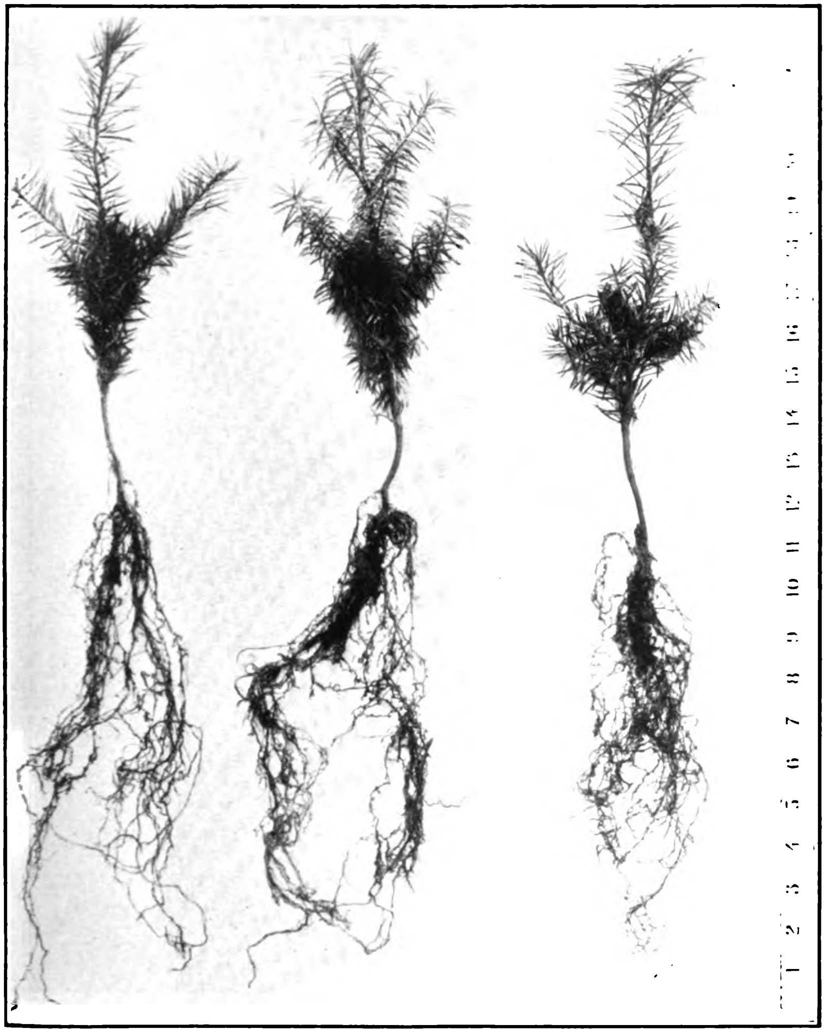
**FIG. 2.—CONCRETE ROLLER FITTED WITH WOODEN CLEATS FOR MAKING DRILLS IN SEED BEDS.**



1-1 DOUGLAS FIR FROM SPRING-SOWN SEED, WIND RIVER NURSERY, COLUMBIA NATIONAL FOREST.

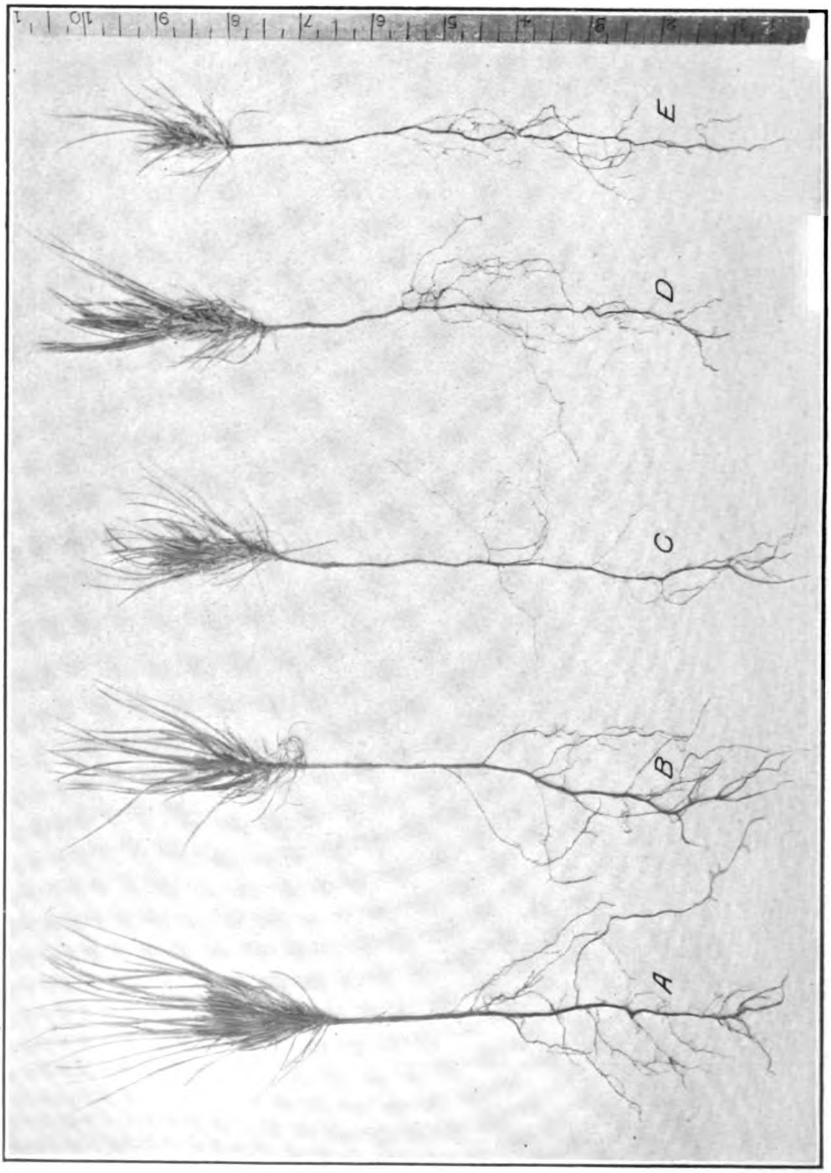
Compare with that from fall-sown seed. Note greater development of latter (Plate V).



F—8794A

1-1 Douglas Fir from Fall-Sown Seed, Wind River Nursery, Columbia National Forest.

Compare with that from spring-sown seed (Plate IV).



COMPARISON OF SEEDLINGS GROWN UNDER DIFFERENT DEGREES OF DENSITY.

*A*, Grown 4,000 per bed; *B*, grown 6,000 per bed; *C*, grown 8,000 per bed; *D*, grown 10,000 per bed; *E*, grown 12,000 per bed.

drills), and length of time that the stock is to be left in the seed beds. The optimum density must be determined through experience. Too heavy stands make the stock spindly, and necessitate more seed, more work, and more grading than stands of the proper density (Pl. VI). Very light stands produce seedlings of good quality; but, as the area is not fully utilized, the cost of the stock is greater than it need be. In Table 3 the densities striven for by the nurseries in the region indicated, as well as the season of sowing, are shown.

The density of stocking can be regulated by the amount of seed sown. The density desired and the germination percentage of the seed being known, the number of seed to sow per square or per linear foot may be determined by use of the following formula:

$$\frac{\text{Number of seedlings desired per square foot or per linear foot + from 10 to 20 per cent.}}{\text{Germination percentage of seed.}}$$

If germination is less complete or there is more loss in the seed beds when seed is sown at one season than at another, this will have to be given due consideration. The additional 10 to 20 per cent is to allow for poorer germination in seed beds than that secured in the tests and for losses after germination. To determine the weight of seed to be be sown per seed bed the foregoing formula would have to be multiplied by the number of square or of linear feet per bed and divided by the number of seed per pound of sample.

TABLE 3.—*Seasons sown, and most desirable density of seedlings.*

| Locality and species. | Season sown. | Most desirable density of seedlings. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Per linear foot of drill in drill sowing. | | | | Per square foot in broadcast sowing. | | | |
| | | 1 year in beds,[1] for transplanting. | 2 years in beds. | | 3 years in beds,[2] for field planting. | 1 year in beds,[1] for transplanting. | 2 years in beds. | | 3 years in beds,[2] for field planting. |
| | | | For transplanting. | For field planting. | | | For transplanting. | For field planting. | |
| **West central Montana, altitude 3,150 feet:** | | | | | | | | | |
| Larix occidentalis | April | | | | | 200 | | 65 | |
| Picea engelmanni | do | | | | | | 250 | | 95 |
| Pinus monticola | October | | | | | | 250 | 155 | |
| Pinus ponderosa | April | | | | | 135 | | 65 | |
| **South central Montana, altitude 5,000 feet:** | | | | | | | | | |
| Picea engelmanni | May | | | | | | 240 | | |
| Pinus ponderosa | do | | | | | 165 | | 85 | |
| Pinus sylvestris | do | | | | | 165 | 120 | | |
| Pseudotsuga taxifolia | do | | | | | | 200 | | |
| **Nebraska, sandhill Region, altitude 2,700 feet:** | | | | | | | | | |
| Pinus austriaca | October-November | | | | | 155 | 125 | | |
| Pinus divaricata | do | | | | | 145 | 125 | | |
| Pinus ponderosa | do | | | | | 165 | 125 | | |
| Pinus resinosa | May | | | | | 180 | 125 | | |
| Pinus syvestris | October-November | | | | | 165 | 125 | | |
| **Colorado, east slope of Rocky Mountains, altitude 7,200 feet:** | | | | | | | | | |
| Picea engelmanni | do | 35-50 | 25-35 | | | | | | |
| Pinus austriaca | do | 25-50 | 25-35 | | | | | | |
| Pinus ponderosa | do | 25-50 | 25-35 | | | | | | |
| Pseudotsuga taxifolia | do | 25-50 | 25-35 | | | | | | |
| **New Mexico, southern portion, altitude 6,470 feet:** | | | | | | | | | |
| Cupressus arizonica | April-May | | 25 | | | | 85 | | |
| Pinus jeffreyi | do | 25 | | | | 85 | | | |
| Pinus ponderosa | do | | 25 | | | | 85 | | |
| **Utah, central portion, altitude 7,400 feet:** | | | | | | | | | |
| Pinus ponderosa | September-October | 100 | 100 | 75 | 40 | 150 | 150 | 100 | 60 |
| Pseudotsuga taxifolia | May | 200 | 250 | 135 | 50 | 250 | 250 | 200 | 75 |
| **Southeastern Idaho, altitude 5,200 feet:** | | | | | | | | | |
| Pinus ponderosa | do | | | | | 150 | | 50-75 | |
| Pseudotsuga taxifolia | do | | | | | | 200 | 175 | 125 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Washington, Cascade Region, altitude 1,200 feet:** | | | | | | | | | |
| Abies nobilis | November-December | | | | | 200 | | | |
| Chamæcyparis lawsoniana | April-May | | | | | | 95 | | |
| Larix occidentalis | do | | | | | 120 | 95 | | |
| Pinus monticola | November-December | | | | | 200 | 110 | 60 | |
| Pinus ponderosa | do | | | | | 160 | | | |
| Pseudotsuga taxifolia | do | | | | | 200 | | | |
| Sequoia washingtoniana | April-May | | | | | | | 40 | |
| **Southern Oregon, altitude 1,700 feet:** | | | | | | | | | |
| Pinus lambertiana | October | | | | | 125 | | | |
| Pinus ponderosa | April-May | | | | | 125 | | | |
| Pseudotsuga taxifolia | do | | | | | 125 | | | |
| **Northern California, altitude 4,000 feet:** | | | | | | | | | |
| Abies concolor | | | 60 | | | | | | |
| Libocedrus decurrens | October | 60-80 | | | | | | | |
| Pinus jeffreyi | May | 65 | | | | | | | |
| Pinus lambertiana | October | | 40 | | | | | | |
| Pinus ponderosa | May | 80-110 | 40 | | | | | | |
| Sequoia washingtoniana | do | | | | | 300 | | | |
| **Southern California, altitude 6,000 feet:** | | | | | | | | | |
| Cedrus deodora | April | | 30 | | | | | | |
| Libocedrus decurrens | do | | 30 | | | | | | |
| Pinus jeffreyi | do | | 30 | | | | | | |
| Pinus ponderosa | do | | 30 | | | | | | |

[1] No column for field planting because 1-year old seedlings are not set in the field.

[2] No column for transplanting because seedlings are transplanted before 3 years.

### COVERING THE SEED.

In some cases the seed are covered by the drill itself. In others the covering must be a separate operation. It is ordinarily accomplished by sifting sand or soil over the beds through a screen of about one-fourth-inch mesh. One man can easily cover from forty to fifty 4 by 12 foot beds per day of 8 hours. Skill is required to cover the seed to a uniform depth so as to insure equable conditions and relatively even germination. There is a tendency to distribute the soil too deep over the center of the beds and too shallow along the edges. One method of covering requires a frame and planing board similar to those shown in figure 2. If broadcast sowing is practiced, the frame need not be removed from the time the bed is first leveled until covering has been completed. The soil used in covering is sifted over the seed bed, and a planing board, narrower by the depth to which it is desired to cover the seed than the one used in sowing, is then drawn along the frame. By this means the seed is covered at a very even depth. Some other methods of covering are followed. Soil is shaken off the blade of a shovel over the seed or scattered by hand. In drill beds sown by hand the seed is sometimes covered with the back of a rake or, as in one of the most successful Forest Service nurseries, by drawing the finger through the soil between the rows, thus closing the open drills.

The depth of covering most suitable for any one species varies according to differences in soil and nursery practice. Even under very constant conditions some latitude may be exercised without danger of seriously affecting the germination of the seed or their subsequent pushing through the covering. If heavy clay soil is used as a cover, the maximum depth permissible can not be so great as if a lighter sandy soil is used because the seedlings experience greater difficulty in breaking through. By reason of their greater size and strength seedlings from large seed can more readily push through a heavy covering than seedlings from small seed. Therefore, the former can safely be covered more deeply than the latter.

Less work is necessary to put on a light cover than a heavy one, and the seedlings appear sooner and more evenly in the beds. It is true that with a shallow covering there is greater probability of the soil becoming dry to the depth of the seeds, resulting in damage to them; but this possibility can not be avoided by any depth of covering consistent with good nursery practice. Danger of this nature must be guarded against by frequent watering or by protecting the seed beds. When moisture conditions in the seed beds can be controlled, Forest Service experience indicates strongly that shallow coverings are preferable, from one-eighth inch with smaller classes of seed, such as spruce, the Thujas, larch, lodgepole pine, and red pine, to three-eighth inch with larger seed, such as white pine, Douglas fir, western yellow pine, and Jeffrey pine. Germination is better and more uniform, and at the Bessey and Savenac nurseries damping-off is less severe in shallow than in deeply covered beds.

A loose, friable soil, such as sand or a mixture of sand and loam, makes the best cover. A cover of sand gives quicker and more uniform germination than any other; it can be put through a screen more easily; it retards evaporation excellently, more effectually prevents caking of the surface and the lifting of cakes bodily by the germinating seed; it decreases the danger of damping-off, and it gradually improves the texture of a heavier underlying soil. Furthermore, moss is less likely to form on a sandy than on a loamy surface.

## COVERING OF THE SEED BEDS.

After sowing and covering the seed there is, at some nurseries, an advantage in covering the seed beds. Protection of the seed against rodents, particularly mice and chipmunks, and of the seedlings (when they first appear above the surface of the soil with the seed coat attached) against birds is very often necessary. A common and effective means of protection is a screened frame cover of the same size as the seed beds, ordinarily 4 by 12 feet, the bottom sill sunk into the soil around the seed bed, and the top high enough above the bed so as not to interfere with the development of the seedlings. The top is removable to permit weeding. Such a frame, called a "Pettis frame," is described in Forest Service Bulletin 76, and the drawings are reproduced here (fig. 4).

A modified type of this frame is used at the Wind River Nursery. The corner and side posts project an inch above the top plate in order to hold the cover in place on the frame. Further, the sides and ends are constructed separately and the frames afterwards set up. This method of construction results in two posts at each corner, one of which fits in front of the other. The frame is set up by bolting the two corner posts together or simply by inserting a large 20d. nail in the hole bored for the bolt. The principal merit of this is that the frames can be quickly taken apart and when stored require much less space.

Before construction the framework material should be painted to preserve the frames and improve their appearance. Experiments at the Wind River Nursery indicate that a light grade of creosote applied to the lower sill of the seed-bed frame will not harm Douglas fir seedlings if not more than two coats are given. Carbolineum of the grade used proved unsatisfactory. Both of these preservatives vary so much in grades that in general it is unsafe to use them unless they have been proved satisfactory by experiment.

Wire mesh for covering the frames can be purchased in rolls 150 feet in length and in widths of 4 feet for the top screen and 1 foot for the sides and ends of the frames. The 1-foot strip is cut in 6-inch widths. Experience at Forest Service nurseries has demonstrated that screen as fine as three meshes to the inch is necessary to keep mice out of the seed beds.

The cost of these frames complete, including a shade frame of lath, is from $3 to $7 each, depending upon the lumber used and the skill and wages of the men who construct them. Money can be saved by purchasing material which is surfaced on four sides, since it can be painted much more rapidly and requires less paint. Such frames ordinarily last only from 3 to 5 years or will need repairing by the end of that time. The bottom sill in particular is very liable to rot.

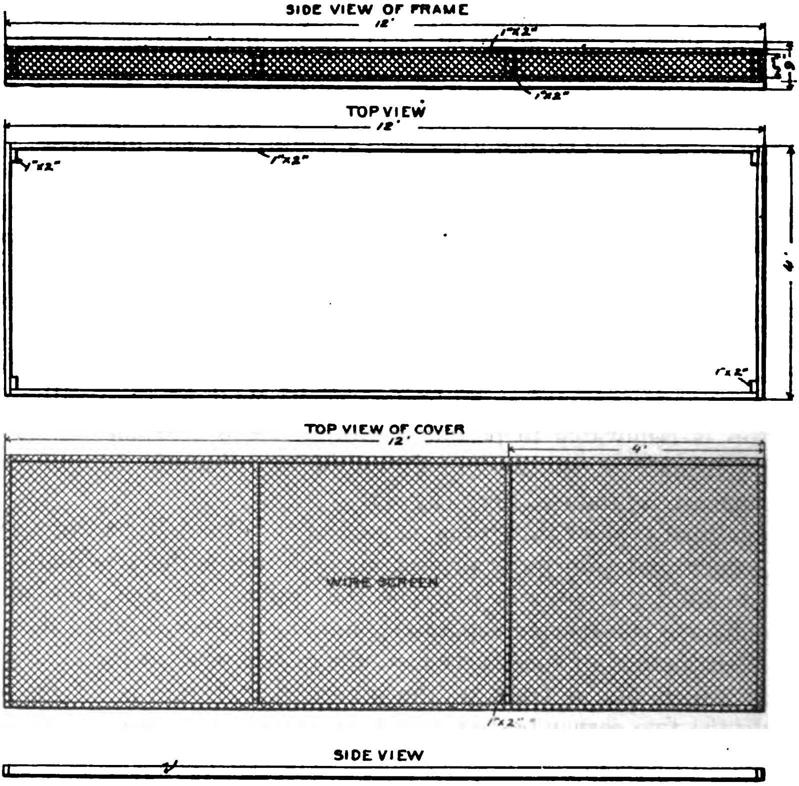


Fig. 4.—Pettis seed-bed frame.

At the old Garden City Nursery protective frames were used whose sides and ends were of 1 by 8 inch boards, the top only being covered with wire screen. These were more satisfactory at this nursery because they afforded a better protection against wind, and were considerably cheaper than the wire frames.

Covering of the seed beds during the germination period is resorted to for other reasons than protection against rodents or birds. Chief among these is keeping the beds as uniformly moist as possible, which undoubtedly promotes the highest germination of the seed. Covering also eliminates the need of such frequent waterings as are necessary in uncovered beds. For the purpose of keeping the beds uniformly moist, the sides and ends of the wire frame just discussed are covered with building, tar, or wrapping paper, or burlap, and a lath shade frame is set on top of it. Burlap is better than paper because it is easier to handle, does not tear, and can be used for two successive years. The lath frame is constructed as shown in figure 5. A complete shade or covering is obtained by laying a loose lath in each interspace between those which are nailed to the frame. Full or partial shade, without the side covering of burlap, is often given the beds by means of this lath frame, some other form of a low-shade frame, or high-shade frames with a slatting cover.

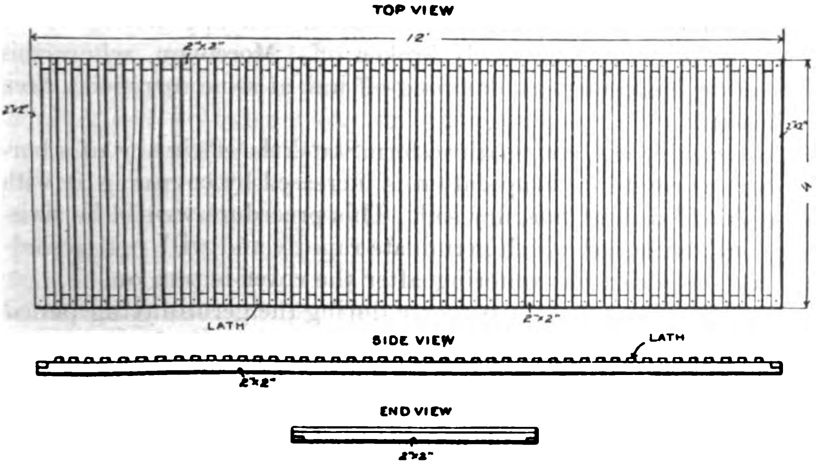


Fig. 5.—Pettis seed-bed frame.

Recent experience has developed the fact that such shade coverings are neither necessary nor desirable in all nurseries where they have been used. This is especially true in the cooler and moister regions and with seed which germinates slowly. Heat as well as moisture is essential for germination of seed; and in moist seed beds tightly screened from the sun's rays, the temperature of the soil may be kept so low as to delay germination considerably. This happened with Douglas fir at the Wind River Nursery. Seed in seed beds without side or overhead cover, or with a cover of one thickness of burlap only, germinated twice as fast in the first month as those under the regular Pettis frames. At the Cottonwood, Pilgrim Creek, and

Monument Nurseries no shade is given until after germination is in progress.

Other covers are often given seed beds to conserve moisture. Burlap is quite commonly stretched flat across the beds, and straw, moss, or leaf mold to a depth of about an inch is sometimes sprinkled over them. Any of these latter coverings must be removed soon after germination commences. For several reasons burlap is the best cover; it can be put on and removed easily; it does not bring weed seed to the bed; it effectually prevents the wind from shifting the surface soil of the beds; it does not mat down and heat; it allows the sun's rays to filter through to warm the soil better than the other covers; and to some extent it protects the beds from birds. Straw, moss, or leaf-mold coverings can not be put on so rapidly nor distributed evenly; they keep the ground cold, thus delaying germination; they often bring weed seed to the beds; they are likely to be blown off by wind; and after germination commences their removal can be accomplished only slowly, not cleanly, and scarcely without damage to numerous seedlings, which when first appearing in the beds are quite brittle and easily broken off. Moreover, where this type of cover has been used, damping-off has, at some nurseries, been more serious.

In the very dry and hot Southwestern States the efficiency of a burlap cover for retarding evaporation is increased by covering it with about one-half inch of fine, dry soil. This procedure would be satisfactory only with seed which germinate rapidly and will not, accordingly, require additional watering after the cover is put on.

In localities where the temperature during the germinating period is very high, where it is very windy, or where the seed germinates very rapidly, the Pettis frame with burlap around the sides and full shade on top is a desirable cover; in cooler localities, especially with slowly germinating seed, no cover at all or simply one of burlap is preferable, provided in each case the sowing operations are conducted in the spring. In seed beds sown late enough in the fall so that there is no possibility of fall germination, no cover at all for the purpose of preventing evaporation is necessary. Protection against rodents, birds, and the removal of the soil by wind is still necessary, and for this the same methods should be followed as in spring sowing.

### WATERING OF SEED BEDS.

Immediately after sowing and covering the seed, the beds should be given a thorough watering. This will usually expose seed which have not been covered deeply enough, settle the soil a little more thoroughly, establish capillarity, and furnish the moisture necessary to initiate germination. Between sowing and actual sprouting, the seed is in its most delicate condition and most subject to loss of vitality from drying out. When germination activities are once started they should not be checked by lack of water. Moreover, insufficient water may cause seed to lie over until the following year before germinating. An uneven-aged stand of seedlings will result. This condition is a nuisance in nursery practice because it necessitates close grading of the stock when it is dug. The moisture condition most conducive to germination is that where the soil is simply fresh or only slightly moist but not wet. An extremely moist or wet soil is not conducive to rapid germination, and may cause the seed to rot. It is not possible to preserve absolutely uniform moisture conditions in the seed beds continuously, but the nearer such conditions can be approached the better will be the germination.

Beds should be watered only often enough to prevent their drying out. The periods of watering will vary so extremely with the character of the season, the soil, and the nature of the covering given the beds that no definite rules can be framed. Inspection of the beds is the only safe guide. It is better to water often and moderately than a few times and heavily. This may mean from once a week or even 10 days under rather favorable conditions or where mulching is practiced to twice a day during very hot, dry weather. When necessary to water daily, it is better to water in the evening than in the morning. When watered in the evening a bed remains moist until the next morning at least, and perhaps until noon. Thus it is sufficiently moist for 18 or 20 hours. When watered in the morning on a clear, warm day, a bed is likely to become dry by sundown, because the greatest evaporation occurs during the middle of the day. Watering later than 3 p. m., however, is considered poor practice at the Pilgrim Creek Nursery, because the seed beds then remain cold over night. The time of watering must thus be related to the daily range in temperature where wide extremes occur.

When fall sowing is practiced or when a rainy season follows sowing, the necessity of watering during the germination period will ordinarily be obviated. In Arizona and New Mexico beds thoroughly soaked before early spring sowing of seed which sprout quickly, and then covered with burlap and about one-half inch of soil, do not need watering during the spring.

A number of methods may be employed: By hand with the hose, by means of garden sprinklers, or by irrigation. The first is slower than the others, but is unquestionably the best from the standpoint of efficiency under all conditions. The water can be distributed evenly in the form of a fine spray to all parts of the beds. Lawn sprinklers are more rapid because as many of them as the water pressure will permit can be kept going at one time. They do not distribute the water so evenly, however, and unless closely attended and frequently shifted, they fail to distribute sufficient water to some portions of the beds, especially the corners. This is particularly true in seed beds with low frames, because these intercept the spray. Nevertheless, when well conducted, this method is quite efficient.

The common lawn sprinkler with three or four whirling arms raised on an 8 to 16 inch standard has proved quite satisfactory. At the Wind River Nursery a wire edge formed on the wearing surface after a while and retarded the motion. Minute débris in the water clogs and stops the sprinklers, and they sometimes leak and wash the soil badly where they are placed. Their cost is from $1 to $1.25 each. Another style of sprinkler which has proved satisfactory is made in a single casting and resembles an inverted bowl or a cone with one or two ¼ or ⅜ inch holes at the apex. The sprinklers throw out an inverted cone-shaped spray to a radius of 10 feet or more. They never clog and their cost is from 15 to 25 cents each. For convenience in dragging it around, each sprinkler can be mounted on a piece of plank about 10 inches square, with two sharp-edge runners on the lower side to prevent its working sideways when drawn over uneven ground in the paths between the beds.

The possibilities of irrigating in seed beds before germination have not been determined for all conditions. At the Pocatello Nursery subirrigation from ditches 3 feet apart was tried. It was found to be satisfactory with western yellow pine but not with Douglas fir. The beds could not be kept moist enough to induce good germination of the latter species. At present sprinkling is followed at all Forest Service nurseries when watering is necessary during the pregermination period, and it is thought that this is preferable to irrigation, whose general practicability is very doubtful.

At a number of nurseries cotton or canvas hose is considered superior to rubber. Second-grade cotton hose lasts two or three years, or about the same as rubber hose; it is much lighter and easier to handle than the latter; it does not damage the stock so badly if dragged across the beds and is cheaper. The ¾-inch size outlasts the 1-inch, because it is more pliable and kinks less easily. At the Pocatello Nursery a crack-proof rubber hose is used and gives very good satisfaction.

## LENGTH OF TIME REQUIRED FOR FULL GERMINATION.

The length of time required for full germination can scarcely be given accurately, because it varies markedly with different soils, different methods of nursery practice, differences in the quality or source of the seed, and variations in the climatic factors. The approximate length of time after spring sowing necessary for practically complete germination is indicated in the following table for several of the Forest Service nurseries:

| Nursery and species. | Germination complete. |
|---|---|
| Savenac: | *Days.* |
| Pinus ponderosa | 25 |
| Larix occidentalis | 40 |
| Trapper Creek: Pinus ponderosa | 24 |
| Boulder: | |
| Pinus ponderosa | 30 to 35 |
| Pinus austriaca | 30 to 35 |
| Pinus sylvestris | 30 to 35 |
| Pseudotsuga taxifolia | 40 to 50 |
| Monument: | |
| Pinus ponderosa | 10 to 18 |
| Pinus austriaca | 10 to 15 |
| Pseudotsuga taxifolia | 10 to 15 |
| Picea engelmanni | 10 |
| Bessey: | |
| Pinus ponderosa | 9 to 20 |
| Pinus divaricata | 9 to 20 |
| Pinus resinosa | 14 to 25 |
| Pinus sylvestris | 12 to 20 |
| Minnesota: Pinus resinosa | 20 |
| Fort Bayard: | *Days.* |
| Pinus ponderosa (summer sowing) | 15 |
| Pinus jeffreyi | 15 |
| Cottonwood: | |
| Pinus ponderosa | 30 to 35 |
| Pinus contorta | 30 to 35 |
| Pseudotsuga taxifolia | 30 to 35 |
| Picea engelmanni | 20 |
| Pocatello: | |
| Pinus ponderosa | 20 to 30 |
| Pseudotsuga taxifolia | 45 to 60 |
| Pilgrim Creek: | |
| Pinus ponderosa | 34 |
| Pinus jeffreyi | 80 |
| Abies concolor | 66 |
| Libocedrus decurrens | 64 |
| Pseudotsuga taxifolia | 58 |
| Wind River: Pseudotsuga taxifolia | 35 to 50 |

### METHODS USED TO HASTEN GERMINATION.

The seeds of a number of conifers germinate so slowly in the aggregate that some method is occasionally used to hasten this function. Western white pine seed is particularly slow, but as yet no successful method of hastening germination has been devised. The seed will not finish germinating in the seed beds for 2 or 3 years, which complicates the nursery operations considerably. A common method tried for various species is to soak the seed in water for a number of days until they swell and begin to sprout. Other methods are to mix the seed with well-rotted compost and soil until sprouting begins, to stratify them in slightly moist sand in a cool place over winter, or to scald bony coated seed in nearly boiling water and allow them to stand in the water for a couple of days.

The efficiency of the first two methods is doubtful. As soon as the seed begins to sprout it is necessary to sow the whole lot, and there is no certainty that the seed have sprouted because of the treatment or that the unsprouted ones have benefited. Even with slow-germinating seed like the western white pine, a small proportion of any lot when simply sown in the beds without previous treatment will germinate in a short time, and it is almost unquestionably these same seed which are the first to sprout under special treatment.

Stratifying in sand over winter in a cool place will undoubtedly hasten the germination of nearly all coniferous seed. The period is long enough so that that the seed have ample time to absorb the moisture necessary for their germination, and the temperature is low enough to prevent germination until the following spring. This method has been followed successfully even with *Juniperus pachy-*

*phlœa* seed, which, like other junipers, ordinarily lies over for a year if sown in the spring without being previously treated.

At the Fort Bayard Nursey fair germination is secured with the seed of *Juniperus monosperma* by removing the hull and then immersing the seed in boiling water for 5 seconds. At the old Garden City Nursery good germination was secured with *Juniperus virginiana* by removing the hulls, soaking the seed in warm water for from 2 to 4 hours, and sowing in the fall.

### CARE OF SEEDLINGS THE FIRST YEAR.

The care of the stock from the time of germination until the plants are ready for field planting has much to do with the mortality, the development of tops and roots, and the final success of the field planting. Operations should be directed toward developing the type of plant most suitable for field planting and toward growing the greatest possible number of these in the allotted space. Wide experience in the United States and Europe has fully demonstrated that plants with stocky tops, thick stems and compact-growing shoots, and compact root systems composed of many lateral but not extremely long, fibrous roots, are more likely to succeed in field planting, particularly under inhospitable conditions, than plants with greatly developed tops and long root systems with few laterals. Shading and watering are two of the most important means of producing such plants and of keeping down the percentage of loss in the nursery.

#### SHADING.

The effect of shading is to lower the temperature and increase the relative humidity of the air below the shade frames, diminish evaporation from the soil and plants, increase the height growth of the seedlings, and lessen the amount of watering necessary. It also prolongs the growing period of the plants into the autumn longer than is always desirable, subjecting them to danger from early frosts and sometimes causing the seedlings to reach a size greater than that considered best for transplanting.

The necessity of shading is greatest during the first season of the plants' growth. They are then small and tender and may be damaged by continuous intense sunlight. Their density results in considerable competition for moisture, and the roots are not well enough developed at the beginning of the season to secure moisture at a considerable depth.

The necessity and amount of shading varies with the species, soil, and region. Some species, such as Norway and Engelmann spruce, appear to need considerable shade at all nurseries; others, such as Douglas fir, will thrive without shade in some regions but demand

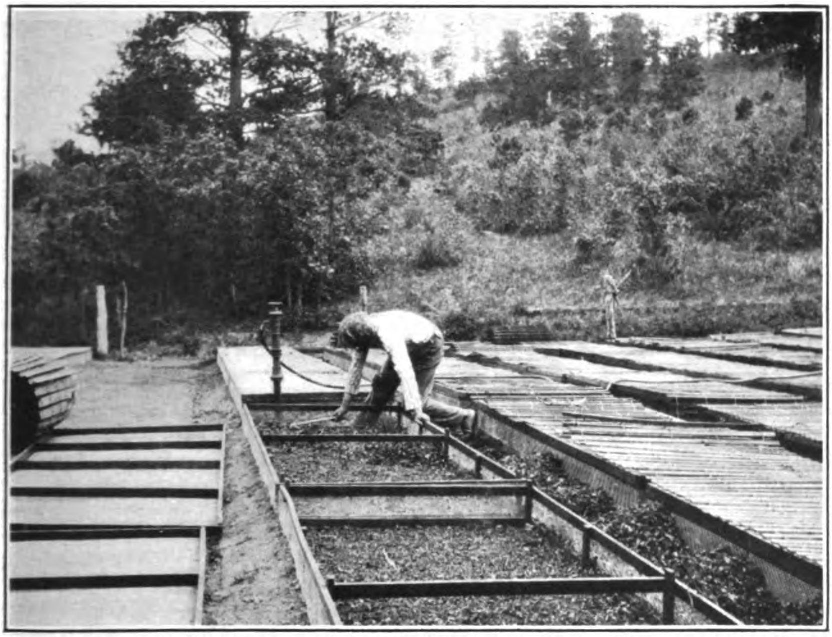


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FIG. 1.—ONE TYPE OF LOW SEED BED PROTECTIVE FRAME IN PLACE, WITH AND WITHOUT COVERS.

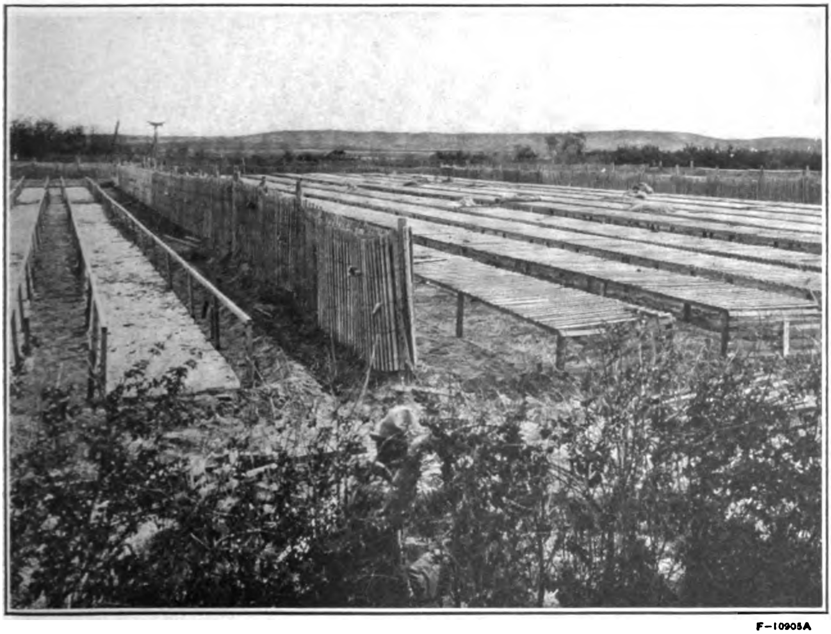

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FIG. 2.—TYPE OF LOW SHADE FRAME IN USE AT THE BESSEY NURSERY.

Some of seed beds covered with burlap.

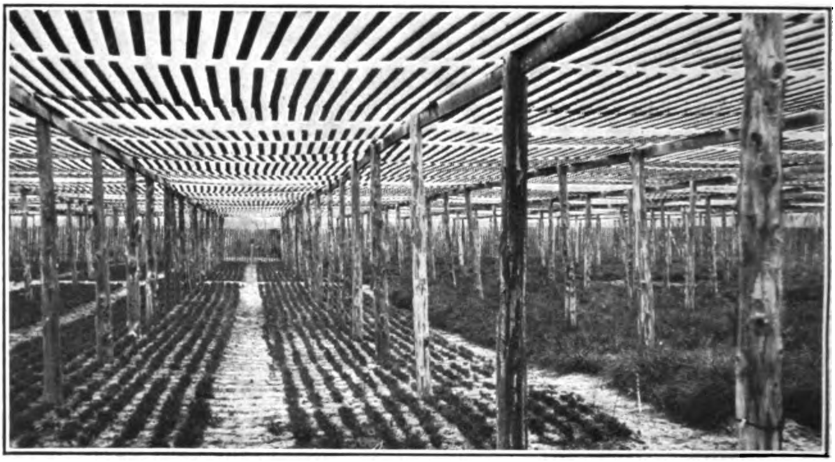

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FIG. 1.—HIGH SHADE FRAMES.

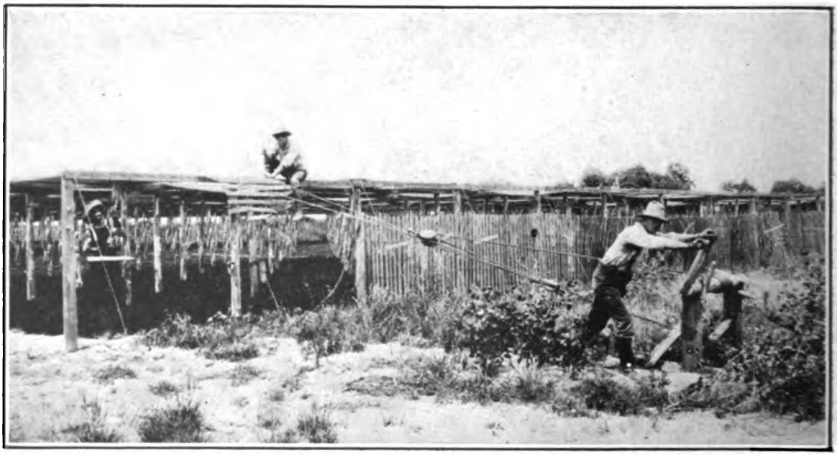

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FIG. 2.—ONE METHOD OF TIGHTENING UP SLATTING COVER ON TOP OF HIGH SHADE FRAMES.

it in others. Without shade, seedlings may thrive on the richer, more retentive soil of a nursery but make poor growth on less fertile soil. Because the period of their initial growth falls in the early spring, when the weather is not extremely hot, seedlings from fall-sown seed are not so likely to need shade as those from spring-sown seed.

At the Savenac Nursery, in western Montana, western yellow pine is grown without shade, but the eastern and western white pines, Engelmann spruce, western red cedar, and western larch need partial shade during hot weather.

At the Boulder Nursery, in southwestern Montana, western yellow pine is grown without shade, but Douglas fir and Engelmann spruce require it during the first year.

At the Bessey Nursery, in the Nebraska sandhill region, all coniferous species are shaded during the first year.

At the Monument Nursery, in central Colorado, one and two year old Engelmann spruce and Douglas fir are given shade.

At the Fort Bayard Nursery, in southern New Mexico, shade is unnecessary with western yellow and Jeffrey pines, and *Juniperus monosperma*. Shade is given *Juniperus scopulorum* and *Cupressus arizonica*, but it is not known to be needed.

At the Cottonwood Nursery, in north-central Utah, western yellow, Scotch, and Austrian pines need no shade; Douglas fir can sometimes be grown without it, but usually Douglas fir, the larches, and Engelmann spruce require it for their best development.

At the Pocatello Nursery, in southeastern Idaho, western yellow pine does not need shade, but Douglas fir does.

At the Wind River Nursery, in southern Washington, all one-year seedlings from spring-sown seed are shaded, but Douglas fir and western yellow pine from fall-sown seed thrive satisfactorily without it.

At the Pilgrim Creek Nursery, in northern California, western yellow pine is grown without shade. All other species, including Jeffrey and sugar pines, incense cedar, and white fir are shaded, but it is not known that all need it.

At the Converse Flats Nursery, in southern California, all species grown, including western yellow and Jeffrey pines and incense and deodar cedars, are shaded during their first year.

*Shade frames.*—There are two general types of shade frames used in nursery operations, the high and the low. The most common form of the latter is the lath frame previously described. When in place this frame rests about a foot above the level of the beds and can easily be handled by one man.

A form of low frame used at the Bessey Nursery is about 22 inches high (Pl. VII). Stakes made of 2 by 4's are driven in the paths at 8-foot intervals on both sides of the beds and 2 by 4's are laid on and nailed to these uprights. This makes a line of stringers along each side of the bed extending its entire length. Strips of slat or lath fencing are rolled out over these stringers to furnish shade. The slatting can be handled by one man and can be quickly rolled up if cloudy weather makes this desirable; the stakes and stringers can easily be moved when it is necessary to plow or grade; and the slatting is high enough above the ground so that weeding can be conducted without removing it. One man can construct about 400 linear feet of this type of frame per day.

The posts and framework of the high frames occupy the ground constantly (Pl. VIII). Durable first-class posts about 10 feet long are set in the ground in check rows from 10 to 12 feet apart, so that their tops are about 7 feet above the ground. Two sets of girders of rather heavy material (2 by 6's are preferable to 2 by 4's, as the latter are likely to buckle) at right angles to each other connect the tops of the posts. Over this framework rolls of slatting can be drawn. The framework must be substantially constructed because it is subject to considerable strain when the slatting is drawn across it and because the necessity often arises of a man working on top of it. The rolls of slatting are usually long enough to stretch entirely across the frame and down to the ground on each side so as to afford side shade and also to act as a windbreak. They remain in place from spring until autumn, thus subjecting the plants to half shade during the whole of the season. At the Pilgrim Creek Nursery 4 by 6 feet frameworks of slatting are used instead of the roll slatting. These are easier to handle, but are more easily broken.

The high frames have some advantages over the low ones. They do not interfere with weeding, cultivation, or watering, so that an inspection of these operations can more easily be made. The working conditions beneath them are more pleasant during extremely hot weather than in the open. The light is more diffused than under low frames, which is desirable in especially hot regions or when the species grown are susceptible to injury from the sun's rays. Under them the paths are kept moist as well as the beds; there is less danger of the stock being harmed by unseasonable frosts; the soil seems less liable to bake and crust than under low frames; and since the slatting remains on during the entire growing season, less watering is needed than with low frames, which are often removed. Their cost of construction of 2½ to 3½ cents per square foot is much less than that of the low wire protection and shade frames, and their life is considerably longer.

Objections to the high frames are numerous. They do not give adequate protection against birds and rodents. Two or more men are required to put the slatting on or take it off, and it takes from 7 to 10 days per acre (two men from 3½ to 5 days) to complete the operation. The slatting is inconvenient to remove so that small areas under it can not be shaded or uncovered according to the requirements of the different species. The posts do not readily permit of plowing and harrowing in preparing the ground, so that these operations are more expensive; and they also interfere in the laying out, sowing, and covering of the beds. Rain collecting on and dripping from low points on these frames washes out either seed or seedlings. The frames do not hold a mulch in place well. At Forest Service nurseries high frames are being used less and less.

In case of emergencies, brush frames can be used. The principle of these is to use brush to furnish the shade. In high frames additional light stringers may be necessary to support the brush because of its irregular size. For this purpose wire serves very well. Brush frames have some advantages; there is no material quite equal to brush as a light filter; it is cheapest when the nursery is located in a remote region with poor communication by wagon road to a source of lumber supply; it is more easily removed after a heavy snow than sections of lath roofing; and it can quickly be put up if a special need for shade should suddenly develop at a nursery. On the other hand, it has disadvantages; the leaves and small twigs are continually falling on the plants and must be removed to prevent smothering; the brush is very inflammable, and it is not easy to spread, especially on high frames. Brush when used should be of as heavy foliaged species as are available.

### REMOVAL OF SHADE FRAMES.

The most critical time in growing plants is the 6 weeks following germination, for during this period they are most subject to damping-off. Shading and watering have an important bearing upon the control of this disease. If germination occurs during cool weather or during hot weather when the surface soil is extremely wet, the shade frames should be removed. As soon as the soil surface becomes dry in hot weather, full sunlight is dangerous. It may give rise to "white-spot" injury, regularly confused with damping-off, but caused by overheating the surface soil. The object of the removal of shade frames is to dry the surface soil and lower the air humidity over the beds. This condition is least favorable to the development and spread of the damping-off fungi.

When practicable, the shades should be removed during periods of rainy weather. The water reaches the soil better and the plants become somewhat accustomed to a greater degree of light. It is generally held that during late summer and early fall the shades should be removed gradually; that is, for an increasing period each day, beginning with exposure for a time during the cooler portion of the morning and afternoon and increasing this until, after 10 days or 2 weeks, the shade frames are left off entirely. In Forest Service practice this has not been found wholly necessary. The shades are often left on until the plants become fully hardened. It is certain, however, that the gradual removal of the shade does hasten this ripening process and puts the plants in better condition to withstand frosts. Until the terminal buds are fully formed, the shade frames should be replaced whenever the nights threaten to be frosty.

### WATERING.

In conjunction with removing the shade frames to prevent damping-off, the watering must also be regulated to induce dryness of the beds. During this danger period no more artificial watering should be practiced than is absolutely necessary to keep the plants in good condition. When it is necessary to water daily, the application should be as light as conditions will allow and should be carried out during the morning hours. When watered in the morning, the beds dry out considerably during the day and do not pass the night in a moist condition very suitable to the development of this disease.

When there is no further serious danger from this source, the practice followed in watering should change. Soil moisture has more influence upon root development and perhaps upon the mortality per cent of seedlings after the damping-off period has passed than any other one factor. In seed beds the plants are crowded, and, unless the moisture in the soil is ample, some of the seedlings are killed out in the competition for water. If there is not enough water near the surface, the roots of those which live go deep in their search for it, and the little-branched, undesirable type of root systems is developed.

As water is one of the easiest factors to control, any advantage to be gained from its judicious use should be followed up. The aim in watering should be to attain a much-branched root system, with an abundance of fine feeding laterals within the first 10 inches of depth. To secure such roots the soil should be kept fresh near the surface. The kind of soil has an important bearing on the amount of water necessary. In light, sandy, well-drained soils an abundance of water may be used and will increase the root development, but in heavy clay soil excessive moisture seems to decrease the number of fine feeding roots. At the Boulder Nursery, by abundant watering and by maintaining the stands at about 100 per square foot in sandy soil, 2–0[1] western yellow pine has been produced which, it is claimed, is superior to the 1–1 stock.

Watering may be necessary daily, two or three times a week, once in two weeks, or even less frequently, depending on the weather and the nature of the soil. A brownish, dying condition of the seedlings at the Bessey Nursery, called blight for some time and supposedly due to disease, was later found to be due simply to insufficient water. On the other hand, excessive moisture may produce a yellowish, sickly appearance of the seedlings, and plants in this condition do not recover so readily as when somewhat damaged from insufficient moisture.

The same methods of watering are followed after germination as in the pregermination period. Irrigation by flooding is very successfully practiced in the sandy soil at the Bessey Nursery. The practice of watering by hand with a hose can be discarded. While efficient, it is slow and expensive. The use of lawn sprinklers is the most common method. Half a dozen of these judiciously distributed will water an acre of seed beds per day, and will require but a small portion of one man's time for their attendance.

If applied in the late afternoon or evening, the water has an opportunity to soak into the ground with less loss from evaporation than if applied in the morning. It is not always possible to defer watering until late afternoon or early evening, however, and damage from sunscald seldom results from watering at any time of day. The danger of seedlings being scalded by water and sun together if the water is applied in the morning or during the middle of a hot day has, in Forest Service nurseries, been found to exist only with stock of bigtree (*Sequoia washingtoniana*) at the Pilgrim Creek Nursery and black locust (*Robinia pseudacacia*) at the Garden City Nursery.

The periods between watering should be progressively lengthened after the growing season is from one-half to two-thirds over, so as to induce the formation of terminal buds and the hardening of the wood. This is essential. If heavy watering is continued until fall and is accompanied by warm weather, seedlings may continue growth until the season of heavy frosts. The plants are liable to serious damage by frost if they are in a succulent growing condition, and it is obvious that they should be hardened if possible. Withholding water and exposing the plants to sunlight is considered one of the best methods of accomplishing this result.

If the soil is exceptionally dry just before winter sets in, the beds should be given a thorough watering to lessen the probability of winter killing or drying out.

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[1] 2–0 stock is that which is grown two years in the seed bed and not transplanted. 1–1 stock is that which is grown one year in the seed bed and one year in the transplant bed.

### WEEDING AND CULTIVATING.

Weeding in seed beds is usually a hand operation because the seedlings or rows of seedlings are too close together to permit the use of hand cultivators. Weeds are most easily removed when the beds are moist. They should not be allowed to become so large that their removal will disturb the seedlings, but there is no necessity of removing them when they are very small. Such work is slow and tedious. The removal of weeds improves the growing conditions for the stock by eliminating competition for light and soil moisture.

Cultivation is not practiced extensively in seed beds at Forest Service nurseries, except to check damping-off. Broadcasted beds do not permit it; and where a good water system is installed it is not essential for the purpose of conserving moisture. Watering is efficient and cheaper. In heavy soils which bake and crust after watering, however, cultivation is desirable. It breaks up the crust and insures a better aerated and warmer soil, a condition which tends to the development of larger and better stock. Where the stock is in rows 6 inches or more apart, hand cultivators can be used. Improvised rakes with tines of 8d and 10d finishing nails are sometimes used, but are not very satisfactory. Garden rakes and potato hooks with some of the tines removed, or very small hoes, are quite effective.

### WINTER MULCHING.

Some soils are subject to heaving caused by alternate freezing and thawing during the winter and spring. When this occurs plants are liable to be lifted with the soil and a portion of their roots broken off. Thin stands of seedlings and seedlings with shallow root systems are most subject to this damage. When the soil resumes its normal position the plants remain sticking up above the beds or else topple over. It is not a practicable operation to reset them in the ground, and they are usually a total loss. Winterkilling due to excessive drying of the tops of stock when the ground is frozen and the roots unable to secure water is another source of danger. Where necessary, then, precautions should be taken to guard against these two sources of loss.

For protection against heaving and winterkilling good, clean straw, marsh hay, or leaves and twigs free from seed can be used as a mulch. At the Monument Nursery oak brush, cut in August to retain the leaves, gives splendid results for winter mulch on yellow pine. A cover used with success on the Minnesota National Forest is burlap of one thickness. After the first fall of snow of 1½ inches, which sifts in and around the seedlings, nearly covering them, the burlap cover is put over the beds and secured in place by the edges of the seed-bed frames, which are left on the beds over winter. This cover has the advantage of being easy to put on and remove, and it does not bring weed or grass seed to the beds. The last consideration is a very important one, since weed or grass seed brought in with a mulch is likely to impede nursery operations very seriously and add to their cost. A mulch should not be put on thickly enough to heat and should lie as loosely as possible. If winterkilling is probable, the tops should be covered; if only heaving threatens, just the soil around the roots need be covered. The mulch should be distributed after the ground is well frozen in the fall and removed in the spring before growth starts and as soon as there is little danger of serious freezing at night. It can be prevented from blowing away by covering the seed beds with the protective frames.

When snow comes early in the fall and lies until well into the spring it serves as a cover and usually makes artificial mulching unnecessary. In fact, where there is such a snow cover an artificial mulch in addition is very likely to cause heating and molding of the plants. Where the winters are cold and windy and the snowfall light mulching is generally considered advisable, but its absolute necessity can be determined only by trial. As the operation is expensive it should not be practiced unless essential. In Forest Service work it is practiced with all species only at the Monument, Converse Flats, and Gallinas Nurseries. To prevent winterkilling it is necessary to mulch 1-0 Arizona cypress at the Fort Bayard Nursery and white and Douglas firs and incense cedar at the Pilgrim Creek Nursery. At the Pocatello and Trapper Creek Nurseries mulching is not practiced; but at the former some loss in Douglas fir is experienced from winterkilling, and at the latter a similar loss in western yellow pine has occurred where the snow blew off the beds in midwinter. At the Cottonwood Nursery mulching is attended by a loss from heating and by molding due to the heavy snowfall, but some loss from spring heaving occurs there in thinly broadcasted beds of 1-0 Douglas fir, Engelmann spruce, and Norway spruce, and in drill-sown beds of the last two species. At the Wind River and Boulder Nurseries mulching has been found to be unnecessary, and at the former even harmful. At the Monument Nursery a straw covering damages Austrian pine; and at the old Garden City Nursery it was found that heating and molding was much more likely to occur under straw than under a mulch of leaves.

## CARE OF SEEDLINGS IN SUCCEEDING YEARS.

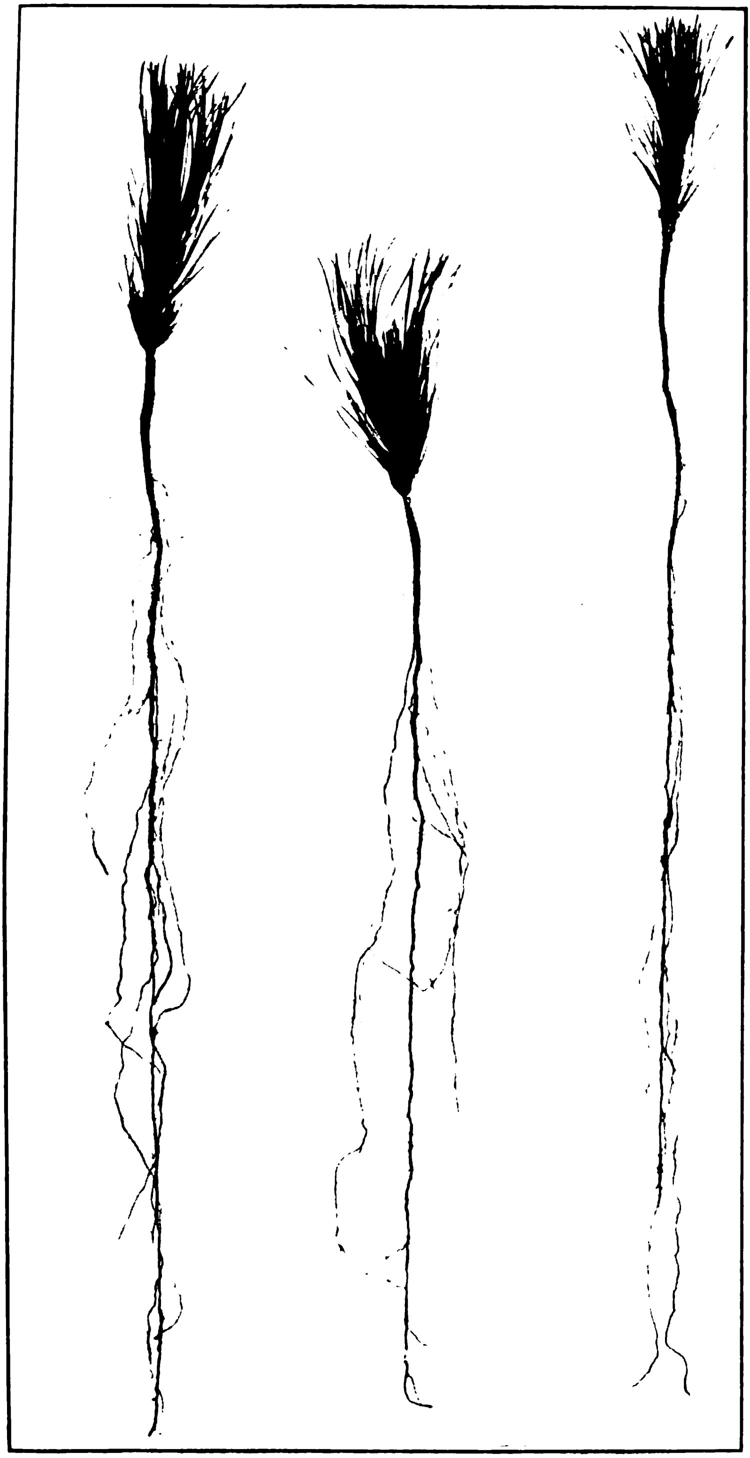
### WATERING, WEEDING, AND SHADING.

When plants are left in the seed beds longer than one year, the cultural operations are very similar to those of the first year. Watering and weeding are carried on as often as appear necessary. Shading is unnecessary with most species, but not with all. Engelmann spruce thrives much better if shaded during the second year at the Boulder, Savenac, and Monument Nurseries. The same is true with bigtree at the Savenac, Douglas fir at the Pocatello, and western red cedar (*Thuja plicata*) and Norway spruce at the Wind River Nursery. At the Converse Flats Nursery 2–0 Jeffrey pine and 2–0 incense cedar are shaded, but it is not known to be necessary. At the Page Creek Nursery the shading of sugar pine in its second year in the seed beds has proved undesirable, because the seedlings when shaded reach a size larger than is convenient for transplanting.

### ROOT PRUNING.

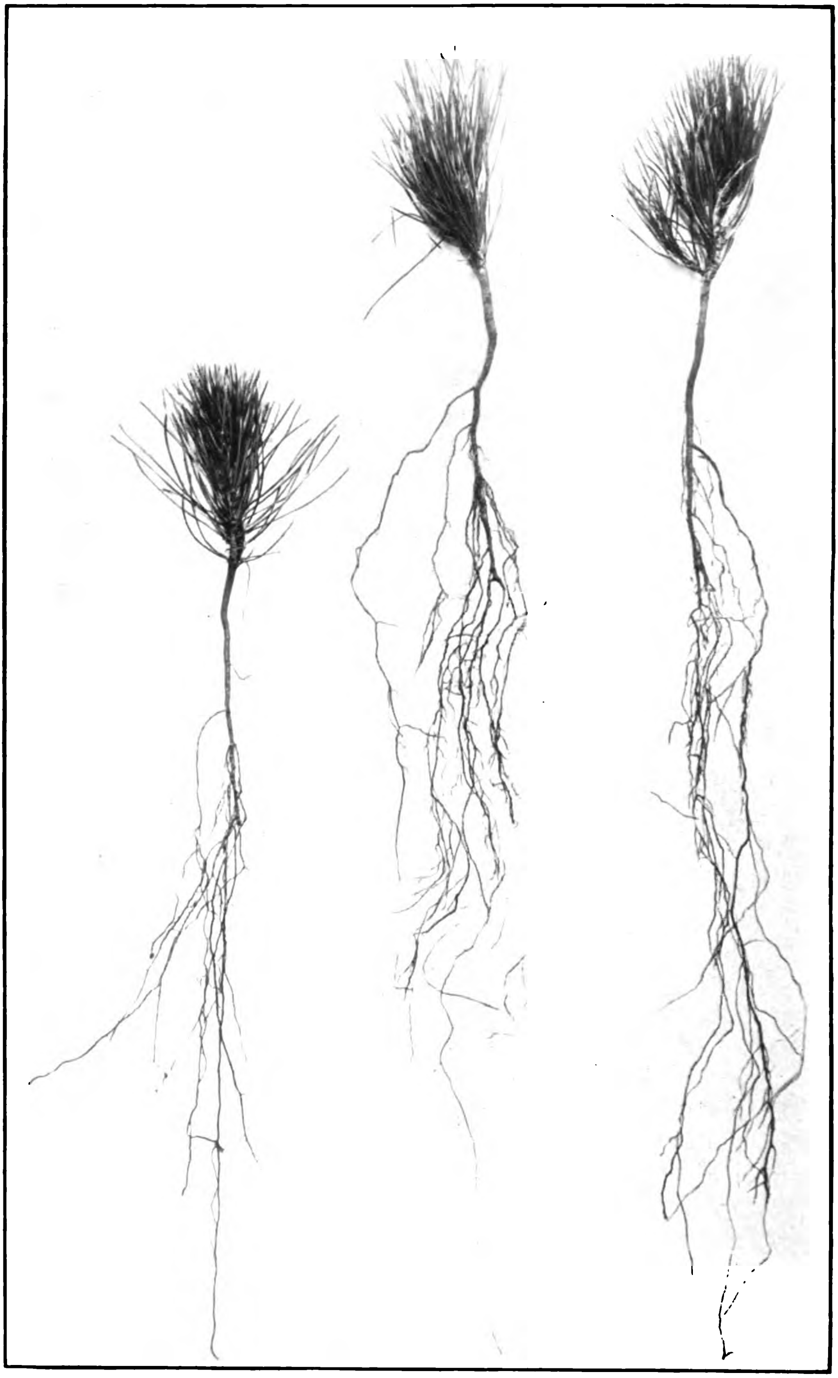
Root pruning is the cutting off of the lower part of the roots of seedlings without removing them from the beds. Its object is to promote the growth of lateral finely branched roots and a stocky top (Pls. IX and X). It is especially worthy of trial for species with very pronounced taproots or with any species when field planting is to be attempted with seedling stock. It is a practicable operation only when the seedlings are grown in drills or in narrow broadcasted strips. It has not been tried extensively at Forest Service nurseries, and the results of the practice are not yet conclusive.

One type of pruner that has been used is a large butcher knife, which is thrust into the ground between the rows at an angle of about 45° and then drawn along so that its edge severs the roots about 6 inches below the surface of the soil. Another is a heavier blade about 12 inches long which is bent below the middle and has its lower cutting end slanted somewhat downward. It has two handles at right angles to each other and about 8 inches apart. Before starting to prune with this tool the soil between two rows of trees is cut with a spade, then the bent end of the pruning blade is dipped into the soil at the end of a row and drawn along as in shaving at any desired depth under the surface. The tool most commonly used is a sharp spade, which is driven into the soil at an angle along one or both sides of a row of seedlings and thus cuts off a portion of the roots. The advantage of using a spade is that it can be operated more rapidly than the other tools and can be used even in stony soils. The other tools are not very efficient under any condition, and are especially impractical in stony ground because they are quickly dulled. In Australia root pruning with spades is practiced even where broadcast sowing is done in long strips 12 to 13 inches wide. Two men with sharp spades work together. Facing each other on opposite sides of a strip, each thrusts a spade into the soil on his side of the row, guiding it at an angle of about 45° downward and toward the center of the strip. The spades meet, practically insuring the severance of the lower portions of the roots of all seedlings in the strip.



3-0 WESTERN YELLOW PINE, BEAVER CREEK NURSERY, WASATCH NATIONAL FOREST. STOCK NOT ROOT PRUNED.

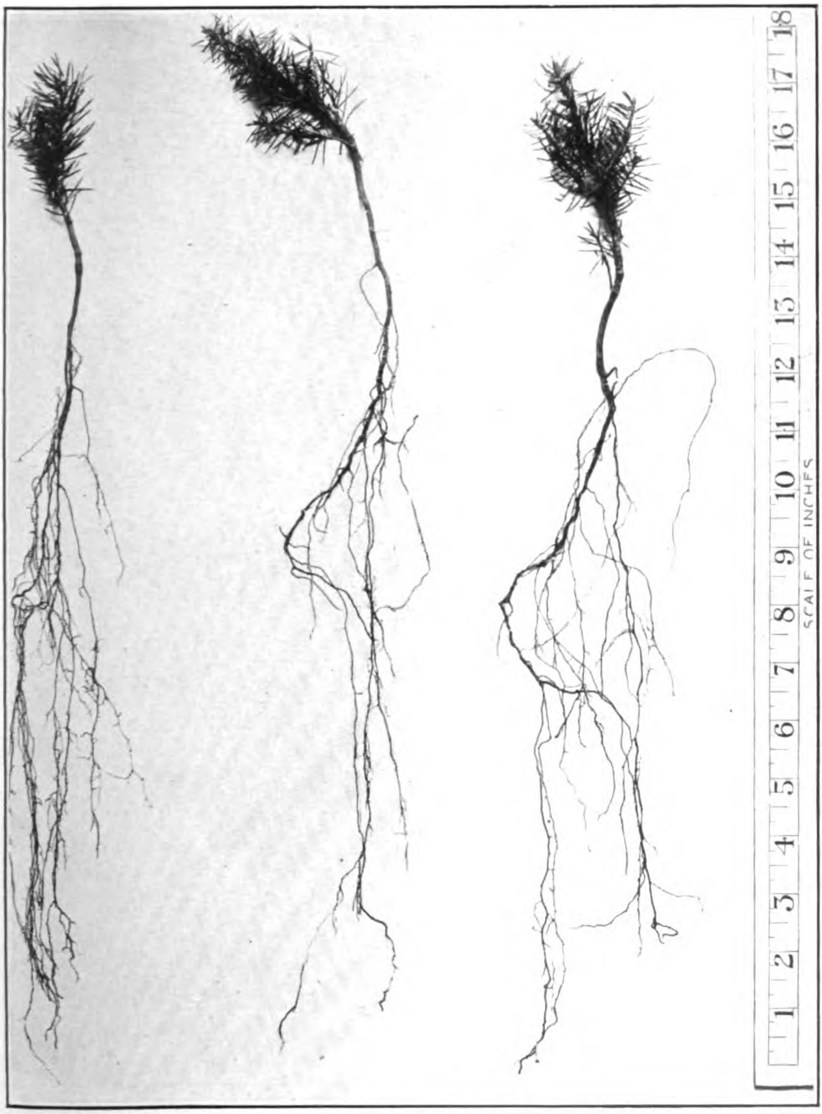
Note better development of roots on root-pruned stock (Plate X).



F—7000A

3-0 WESTERN YELLOW PINE, BEAVER CREEK NURSERY, ROOT PRUNED IN THE SPRING OF ITS THIRD YEAR.

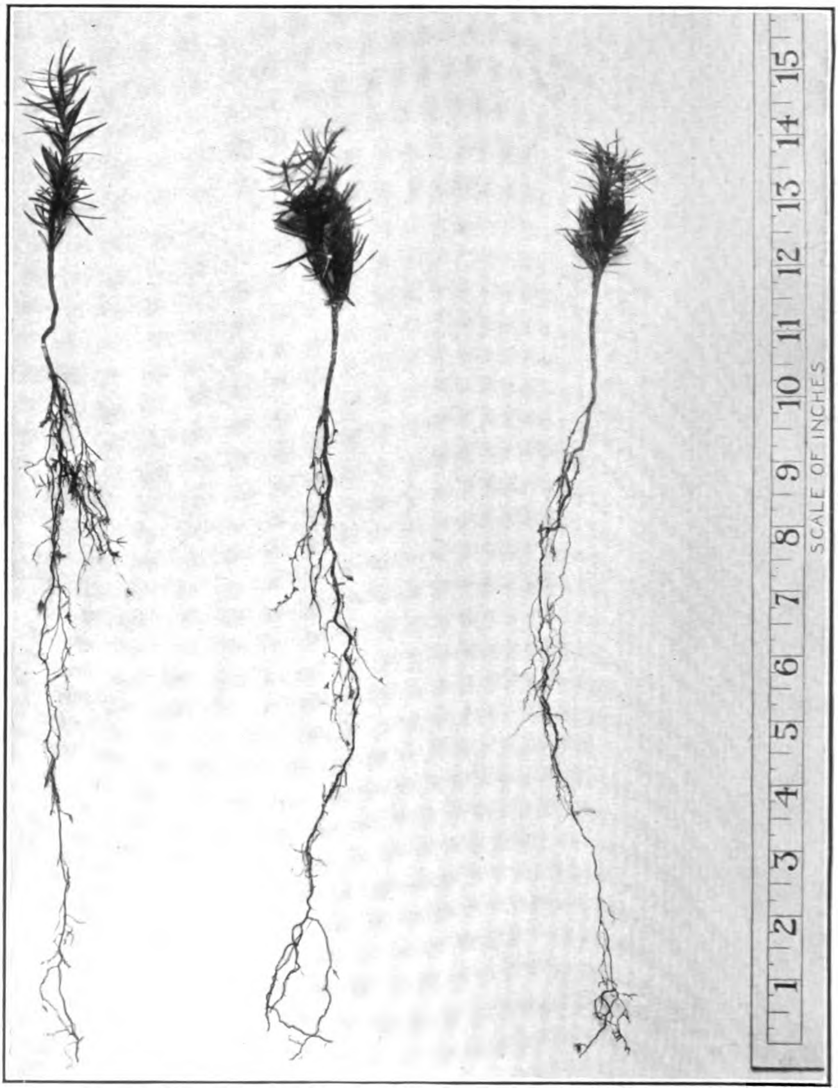
Note better root systems than on unpruned stock (Plate IX).



F-5915A

2-1 DOUGLAS FIR, BOULDER NURSERY.

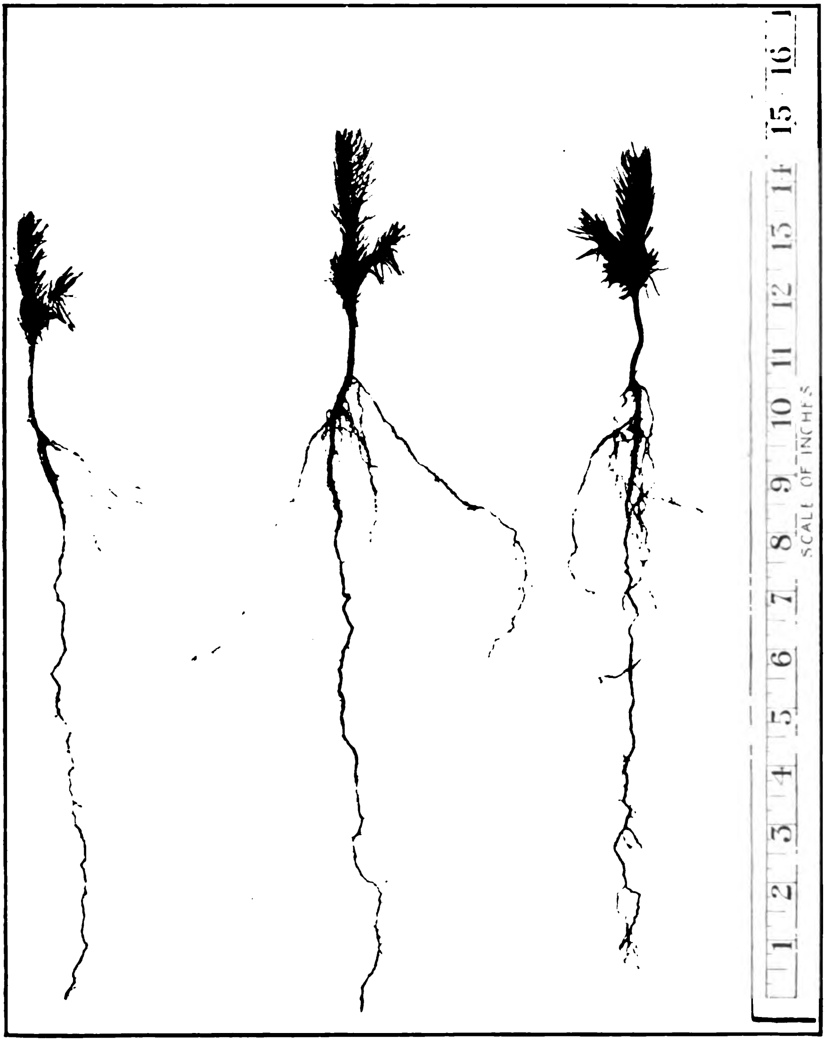
Compare root development with that of same age (3-0) seedling stock (Plate XII).



F—8016A

**3-0 DOUGLAS FIR, BOULDER NURSERY.**

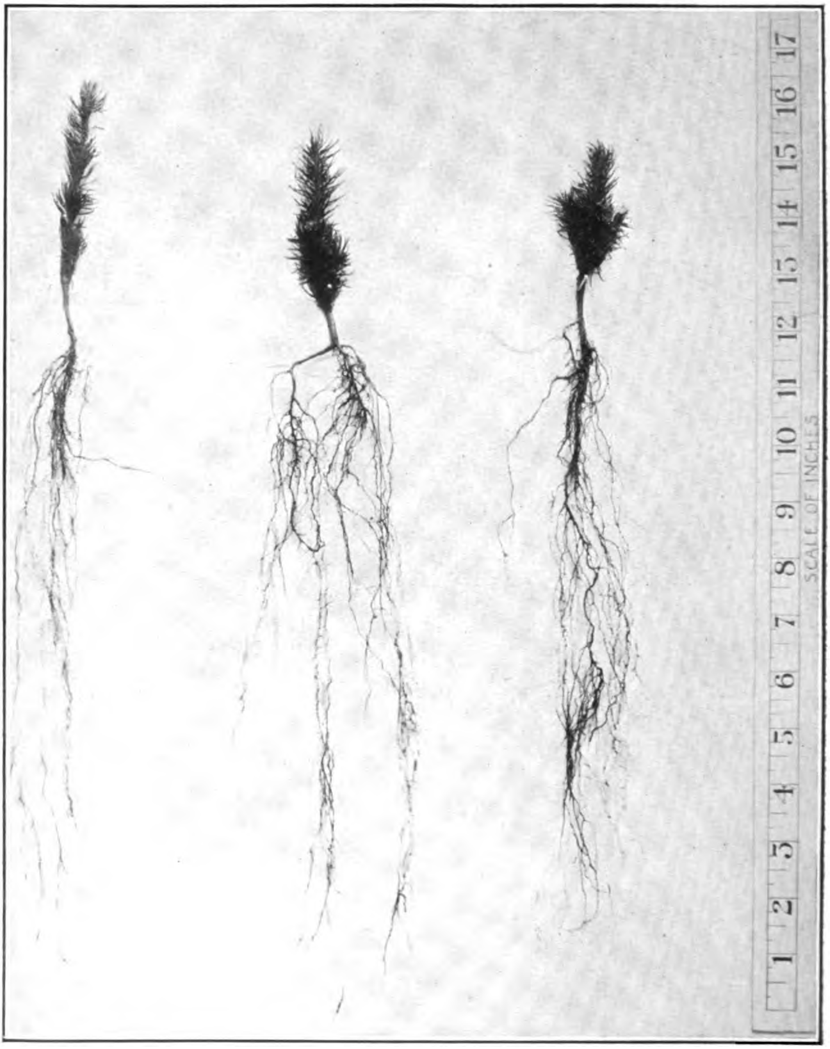
Compare root development with that of same aged (2-1) transplant stock (Plate XI).



F–6909A

3-0 ENGELMANN SPRUCE.

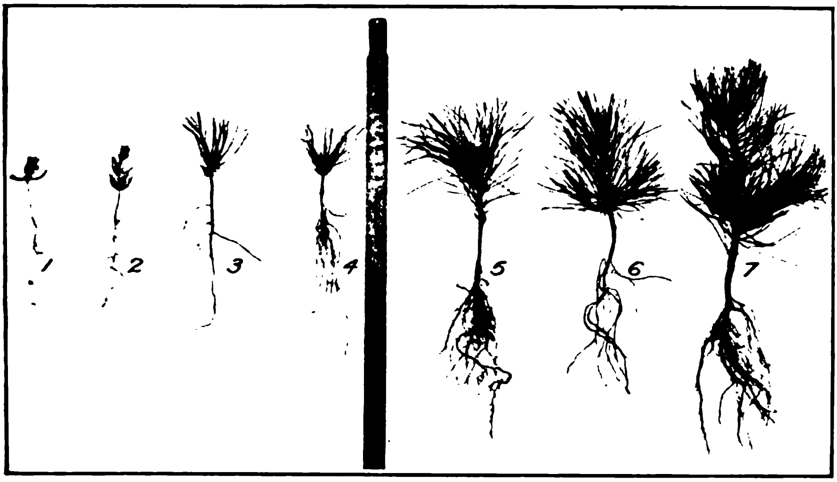
**Compare root development with that of same aged (2-1) stock (Plate XIV).**



F–8010A

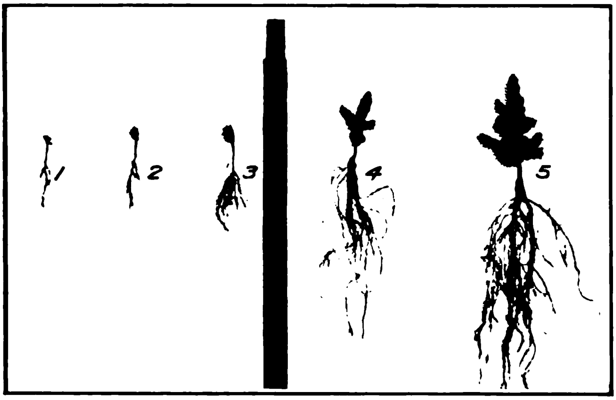
2-1 ENGELMANN SPRUCE.

Compare root development with same aged (3-0) seedling stock (Plate XIII).



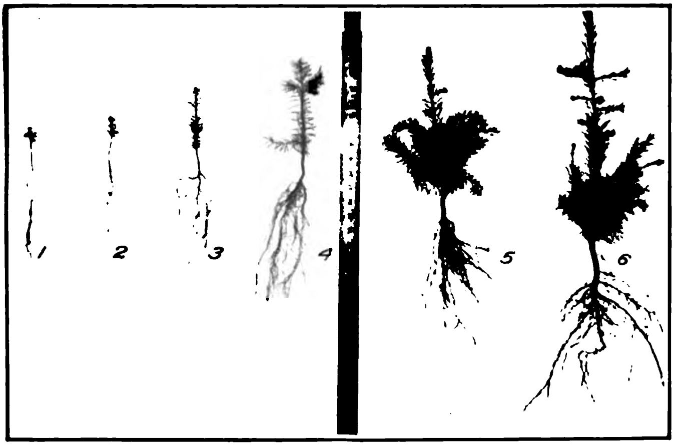
F—19068A

FIG. 1.—WESTERN YELLOW PINE: 1, 1-0 FROM SPRING-SOWN SEED; 2, 1-0 FROM FALL-SOWN SEED; 3, 2-0; 4, 1-1; 5, 2-1; 6, 1-2; 7, 2-2.



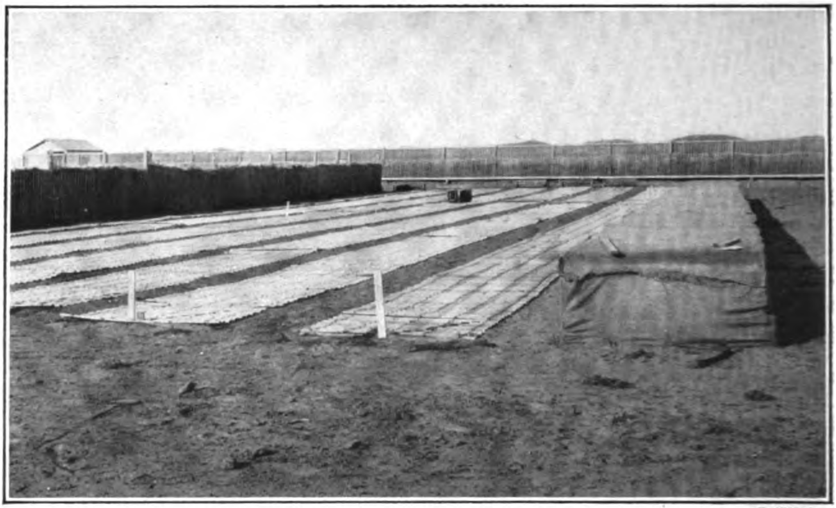
F—19090A

FIG. 2.—ENGELMAN SPRUCE: 1, 1-0 FROM SPRING-SOWN SEED; 2, 1-0 FROM FALL-SOWN SEED: 3, 2-0; 4, 2-1; 5, 2-2.



F—19069A

FIG. 3.—DOUGLAS FIR: 1, 1-0 FROM SPRING-SOWN SEED; 2, 1-0 FROM FALL-SOWN SEED; 3, 2-0; 4, 2-1; 5, 2-2; 6, 2-3.



F—17[illegible]A

FIG. 1.—SIX BEDS AT LEFT SOWN AND COVERED FOR THE WINTER, BESSEY NURSERY.

Bed at right an experiment in the control of damping-off.

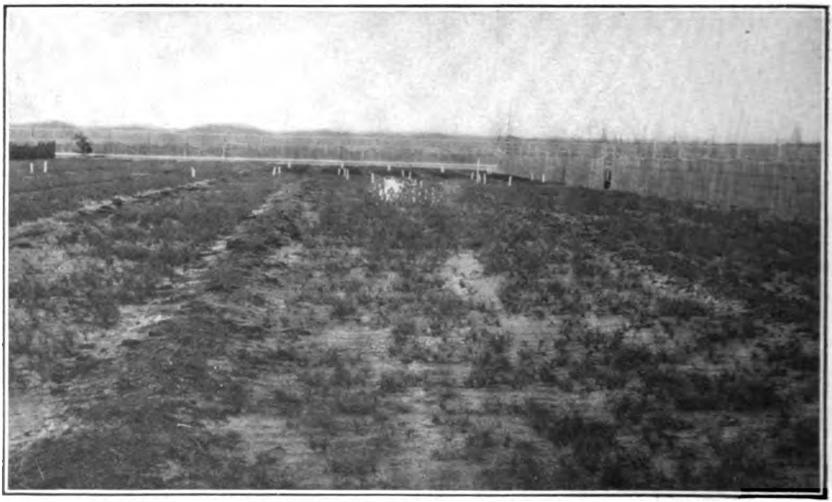


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FIG. 2.—WESTERN YELLOW PINE, BESSEY NURSERY.

Heavy loss due to late spring transplanting.

Root pruning is sometimes practiced during the first season that the plants are in seed beds, but ordinarily it should be done about the time growth is to start, or shortly after, during the second or third season. This gives the plants ample time to recuperate before the end of the season. There is little doubt that by root pruning plants can be produced which will prove more suitable for field planting under adverse conditions than unpruned seedling stock. On the other hand, it is not certain that it will produce stock as suitable for planting on the poorest sites as transplants, and it results in an increase in the mortality of the seedlings. To decrease the possibility of losses the beds should be watered heavily before and again immediately after the operation.

## TRANSPLANTING.

In transplanting, seedlings are transferred from seed beds to other beds, where they are given a uniform spacing and much more growing space.

### OBJECT AND ADVISABILITY.

Transplanting, like root pruning, has for its object the production of stock which is most likely to succeed in field planting, particularly on inhospitable sites. Its effect is to check height growth of the plants somewhat and to stimulate development of the finer, lateral feeding roots (Pls. XI to XV). In the vast majority of cases such stock is more suitable for planting under unfavorable conditions than seedlings. The conditions on much of the area to be planted on the National Forests are more or less inhospitable; the area is so large that rapid planting is desirable both to cover the ground and to reduce costs; and to conduct the planting operations it is often impossible to secure other than unskilled, careless, and indifferent labor, which means that much of the stock will be poorly planted. These factors make imperative the production of stock best suited to withstand them. Since transplanting achieves this result, its general advisability becomes apparent.

As the greatest single expense of nursery operation, however, comes in transplating, this operation may be inadvisable in regions such as northern Idaho, where experience indicates that success may be achieved with seedling stock. Comparative tests of the two classes of stock for each species and region are necessary to determine the final practice in this regard.

### SEASON.

In transplanting, the roots of seedlings lose their contact with the soil of the seed beds and do not function again until they become established in the soil of the transplant beds. During the growing period the crowns of the seedlings make constant demands upon the roots for moisture. Since the roots are unable to furnish this immediately after transplanting, it is quite essential, in order to prevent losses, to conduct the transplanting operation during the dormant period of the seedlings, which is normally from fall to spring. Snow and the frozen condition of the soil make transplanting impossible during the winter. It must be done, therefore, either in the spring or fall.

Fall transplanting has only a few advantages. There is not the danger, as in spring, of the plants starting growth before the operation is completed; and the transplants are ready to start growth early the following spring and reach a larger size by fall than they would otherwise. On the other hand, fall transplanting is liable to be stopped at any time by early snow or freezing weather; it necessitates double the regular transplant area in case the stock transplanted the previous fall is not yet shipped; fertilizer crops (where green manuring is practiced) can not be turned under in time to decay before transplanting; and the transplanted stock is likely during the winter to be heaved out of the ground or winterkilled because the roots have not taken a firm hold on the soil. Severe losses of fall transplanted western yellow pine at the Savenac, Pocatello, Uinta, and Pilgrim Creek Nurseries have been caused by heaving.

Spring transplanting is, in general, preferable to fall transplanting. The chief objection to it is that growth in the seed beds may start before the transplanting can be completed, causing loss in the transplant beds. The danger can be obviated by working a large transplanting crew and rapidly finishing the operation. Spring transplanting should be started as early as the condition of the soil will permit and then rushed. At the Bessey Nursery the loss in transplanting jack pine and western yellow pine in April was 12 and 17 per cent, respectively, and increased to 30 and 40 per cent in May (Pl. XVI).

If the beginning of growth threatens or starts before transplanting is finished, there is a possibility that it may be checked, but none of the known methods is highly efficient. One method is to heel the plants in the ground in a cool, shady situation, such as the bank of a small stream where there is good, fine soil. A trench deep enough to accommodate the roots and with one sloping side is dug; the plants are spread out along the sloping side in a layer two or three deep with their tops above the surface of the soil and their roots extended to the bottom of the trench; and the loose soil is then thrown over the roots and packed well. If the soil is dry it is watered immediately and at intervals later on. If no shade is available the tops are loosely covered with some such material as burlap or straw and are examined frequently to observe any heating. Fall heeling in of Douglas fir seedlings for spring transplanting at the Boulder Nursery and of western white pine at the Savenac Nursery proved very unsatisfactory. At the Boulder Nursery the stock appeared fresh and green in the spring, although of a darker color than in the fall. Only a few of the trees had died; but the needles pulled off very easily, indicating a loss of vitality. After transplanting about 35 per cent of the stock died. That which lived started growth very slowly and at the end of the season had developed in size only about one-half as much as seedlings left in the beds over winter (Pl. XVII). An examination of the roots at the end of the growing season revealed the fact that all old laterals had rotted away and that all of those present were newly formed.

Another method is to cover the seedlings while they are in the seed beds with some such material as straw, hay, or shade frames. If straw or hay is used, the seedlings should be examined frequently to detect any heating. At the Fort Valley Experiment Station shade frames are put over the beds after they become snow covered. In the spring these retard for a short time the melting of the snow and the development of the seedlings.

It is possible that an effective method would be cold storage at a temperature just above the freezing point. In Norway, cold-storage houses have been used very successfully for holding plants over in the spring. In the nursery at Softland, on the west coast of Norway, it is stated that Norway spruce can safely be kept in cold storage for 2 months and Scotch pine for 1 month. The plants must not be put into the ice house when wet, however, on account of the danger of molding. No covering whatever is placed over the roots of plants stored in this way. The best plants are secured by having the cellar below the level of the ground. J. Hein's Sons, of Halstenbek, Germany, have their cold-storage house so far below the surface that it is unnecessary to use any ice whatever.

It is much better if none of these methods are necessary. Handling of the plants and exposure of the roots should be avoided as much as possible, for extra handling will manifest itself in greater losses in the transplant beds and will increase costs. In fact, at the Wind River Nursery it is considered better not to remove the seedlings from the beds even if they can not be transplanted until 10 days or two weeks after growth has started. The best results are obtained when the seedlings are transplanted directly from the seed beds.

### PREPARATION OF TRANSPLANT BEDS.

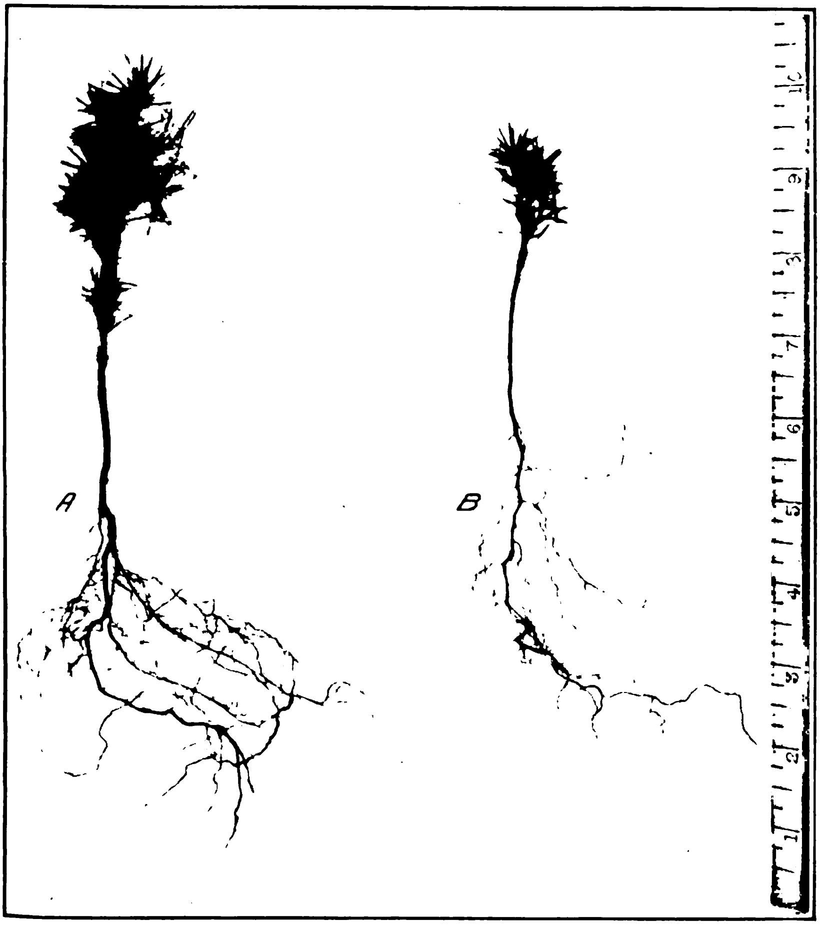
Transplant beds should be given practically the same thorough preparation as seed beds, except that hand spading is unnecessary. The area should be plowed as deeply as possible, because this facilitates transplanting operations. After harrowing and grading all large roots, rubbish, and stones should be picked up and carted away and the smaller trash raked off. The beds are then laid out preferably in some rectangular system and with a great deal of regularity, but necessarily in accordance with what the water system demands. Ordinarily the corners of the beds are marked with stakes, and the beds are separated by paths from 1½ to 2 feet wide at the sides and from 2 to 4 feet wide at the ends. The paths at the ends of the beds generally follow a branch of the water system. A convenient size of transplant bed where sprinkling is practiced is 6 feet wide and of any length up to 100 feet. Solid blocks may be planted, particularly when the rows run lengthwise of the beds. Where subirrigation is practiced the beds can not very well be more than 2 feet wide in order to allow for frequent ditches. After being prepared the beds, if not moist, should be sprinkled thoroughly. This settles the soil, facilitates the opening up of the trenches which are to receive the seedlings, and insures a greater success in the transplanting operation.

### AGE, SIZE, AND SPACING OF TRANSPLANT STOCK.

The principal feature which determines at what age stock should be transplanted is its size. It is slower to transplant very small or very large stock than intermediate sizes. Small stock can be handled only slowly and usually has to be left in the transplant beds 2 years before it becomes large enough for field planting, necessitating a transplant area extensive enough to accommodate 2 years' output of seedlings. Large stock necessitates the digging of deep trenches and wider spacing in the beds and should not be used for transplanting unless the resulting transplant stock is particularly well adapted for field planting.

Coniferous seedlings averaging from 2 to 3 inches in height are the most desirable size for transplanting. If possible, such stock should be produced in 1 year. At the end of 1 year in the transplant bed it is usually well enough developed for field planting. Thus transplants suitable for field planting will be produced in 2 years, and this seems to be the end toward which nursery practice should work. Older stock, however, will undoubtedly continue to be superior under some conditions.

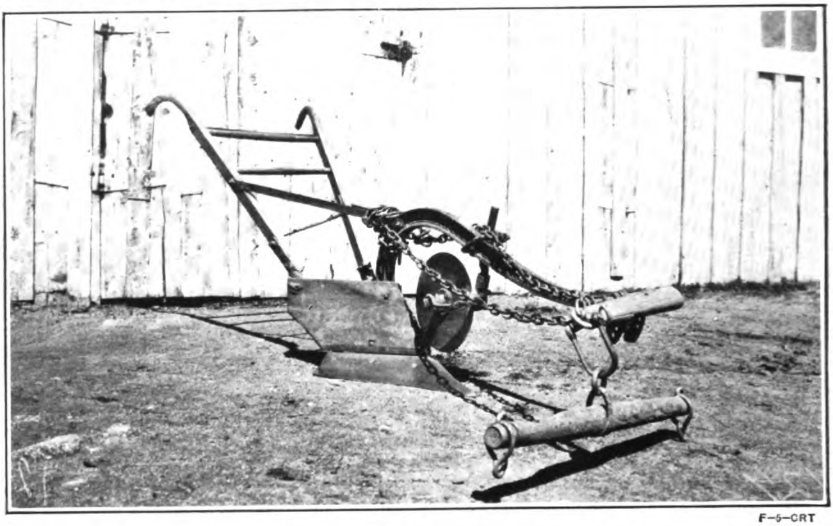
At Forest Service nurseries it has not yet been possible to produce in 1 year stock of all species large enough for transplanting. Some species are inherently of such slow initial growth that they will not reach a suitable size; and some nurseries are located where the growing season is so short that sufficient development is not reached in 1 year. The following table shows the age at which seedlings



F-4-CRT

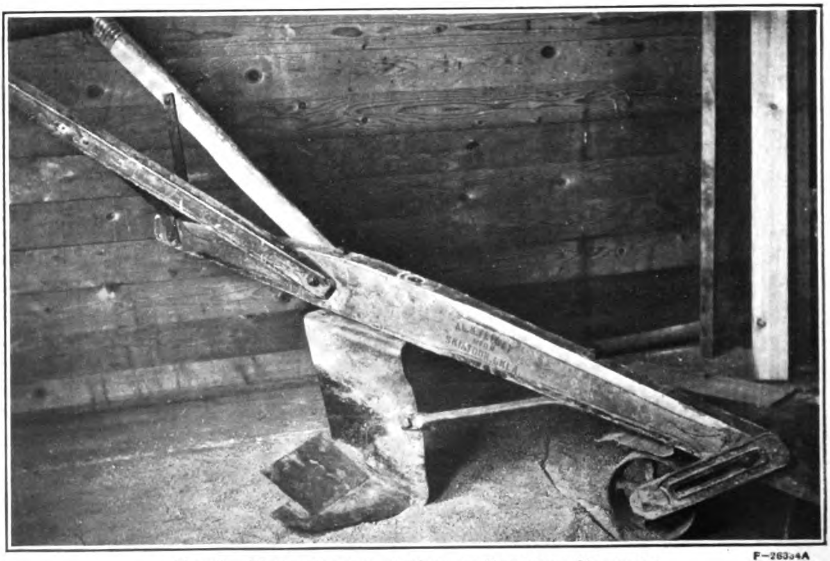
EFFECT OF "HEELING IN" OVER WINTER.

Retarded development of both the root system and crown as compared with the tree which was transplanted direct from the seed bed. *A*. Transplanted in the spring direct from seed bed. *B*. Transplanted in the spring after "heeling in" over winter.



F-5-CRT

FIG. 1.—DIGGING PLOW WITH WOODEN MOLDBOARD IN PLACE FOR DIGGING SEEDLING STOCK, MONUMENT NURSERY.



F-26334A

FIG. 2.—TREE DIGGER IN USE AT SAVENAC NURSERY.

of different species are generally transplanted at the Forest Service nurseries, as well as the length of time that they are kept in the transplant beds:

| Nursery, location, and species. | Class of transplants produced.[1] |
|---|---|
| Boulder, Mont.: | |
| Pinus ponderosa | 1-2 |
| Pseudotsuga taxifolia | 2-2 |
| Savenac, Mont.: | |
| Larix occidentalis | 2-2 |
| Picea engelmanni | 2-2 |
| Pinus ponderosa | 1-2 |
| Pinus monticola | 1-2 and 2-2 |
| Thuja plicata | 2-2 |
| Pocatello, Idaho: Pseudotsuga taxifolia | 2-1, 2-2 |
| Bessey, Nebr.: | |
| Pinus austriaca | 2-1 and 1-1 |
| Pinus divaricata | 2-1 and 1-1 |
| Pinus ponderosa | 2-1 and 1-1 |
| Pinus resinosa | 2-1 |
| Pinus sylvestris | 1-1 and 2-1 |
| Monument, Colo.: | |
| Picea engelmanni | 2-1 and 2-2, 3-1 |
| Pinus ponderosa | 2-1 and 1-1 |
| Pseudotsuga taxifolia | 2-1 and 2-2 |
| Fort Bayard, N. Mex.: | |
| Cupressus arizonica | 1-1 |
| Juniperus monosperma | 1-1 |
| Juniperus pachyphloea | 1-1 |
| Pinus jeffreyi | 1-1 |
| Pinus ponderosa | 1½-1, 2-1 |
| Gallinas, N. Mex.: | |
| Pinus ponderosa | 2-1, 1½-1 |
| Pseudotsuga taxifolia | 2-1, 2-2 |
| Cottonwood, Utah: | |
| Picea engelmanni | 2-2, 2-3 |
| Picea excelsa | 2-1 |
| Cottonwood, Utah—Continued. | |
| Pinus ponderosa | 1-2, 2-1 |
| Pinus sylvestris | 2-1, 1-2 |
| Pseudotsuga taxifolia | 2-2, 2-1 |
| Beaver Creek, Utah: | |
| Pinus contorta | 2-1 |
| Pinus ponderosa | 1-2 |
| Converse Flats, Cal.: | |
| Cedrus deodara | 1-1 |
| Libocedrus decurrens | 1-1, 1-2 |
| Pinus jeffreyi | 2-1, 1-2, 1-1 |
| Pinus ponderosa | 1-1 |
| Pilgrim Creek, Cal.: | |
| Abies concolor | 2-1 |
| Libocedrus decurrens | 2-1, 1-2 |
| Pinus lambertiana | 2-1, 1-2 |
| Pinus ponderosa | 2-1, 1-2, 1-1 |
| Sequoia washingtoniana | 1-1 |
| Page Creek, Oreg.: | |
| Pinus lambertiana | 1-1, 1-2 |
| Pinus ponderosa | 1-1 |
| Wind River, Wash.: | |
| Abies nobilis | 1-1, 2-1 |
| Larix leptolepis | 1-1, 1-2 |
| Picea excelsa | 2-1 |
| Pinus maritima | 1-1 |
| Pinus monticola | 1-1, 1-2 |
| Pinus lambertiana | 1-1, 1-2 |
| Pinus ponderosa | 1-1, 2-1 |
| Pinus resinosa | 1-2 |
| Pseudotsuga taxifolia | 1-1 |
| Thuja plicata | 2-1 |
| Pinus strobus | 1-2 |

[1] The first figure of each pair indicates the number of years that stock is left in seed beds; the second figure, the number of years that it remains in transplant beds.

More than one class of stock of the same species is often produced at a nursery, partly because the best class of stock has not been fully determined, and partly because of the different conditions met in planting operations. One nursery may supply stock for planting on several varieties of sites on each of which a certain class of stock may be most suitable.

In transplanting at Forest Service nurseries spacings not greater than 1½ inches in the rows and 6 inches between the rows are the rule. This allows ample room for root development and for cultivation by hand cultivators. Though closer spacings than this are practiced successfully at some of these nurseries, they are generally considered inadvisable because the roots become intertwined and may be rather badly damaged when the plants are dug up. The common error is to space plants more widely than is necessary. No harm is done the plants by this practice, but it involves the preparation of a larger transplant area, digging and filling of more trenches, setting of more lines, watering and weeding of a larger area, a more extensive watering system, and, in short, a great deal more work and expense than is necessary. When stock reaches a large size before or after transplanting, or where there is a deficiency in the water supply during the growing season, wider spacing is justified. It is thought that 1½-inch spacing in the rows is too close for the large 1–0 fall-sown Douglas fir at the Wind River Nursery, and for 2–0 western yellow pine at Fort Bayard.

### REMOVING SEEDLINGS FROM SEED BEDS OR "LIFTING."

The first step in transplanting is digging the seedlings from the seed beds. The tool best adapted to this purpose under all conditions is a flat, straight-handled spade. In seed beds of 200 seedlings or more per square foot one man can dig and deliver to the planters from 50,000 to 70,000 plants per day of 8 hours, depending largely on the character of the soil and the care taken. The operation consists simply of shoving the spade at a slight angle into the ground at a distance of about 6 inches from and parallel to the outer row, and then, by backward pressure on the handle, loosening and lifting the seedlings from the soil which surrounds them. In drill-sown beds the practice is often to drive the spade in behind the row of seedlings and pry them away from the remaining stand. When the seedlings are thoroughly loosened and the soil around them is shaken apart, they can be removed without serious breakage of the roots. Two men work to best advantage. While one works the spade the other grasps the tops of a bunch of seedlings, and, by a weaving motion accompanied by a slight pull, removes a bunch of plants at one time. This is work which should be intrusted to one or more carefully selected crews. At a number of the nurseries one man does it alone. Before starting the operation, the soil should be fairly fresh. If necessary, it should be watered to secure this condition. Garden forks are sometimes used instead of spades. They can be handled more rapidly, but are very likely to skin the roots.

At several nurseries horse-drawn tree diggers (Pls. XVIII and XIX) are used for both seedlings and transplants. The principal merit of these is that the trees can be dug very rapidly. The sharp-edged horizontal wedge of the digger shown in figure 2, Plate XVIII, is drawn under the trees at any necessary depth down to 12 inches and loosens a strip of plants about a foot in width. It is somewhat difficult to guide accurately, occasionally coming near the surface and cutting off the roots too closely. Some plants also have their roots badly skinned and the tops of others are trampled by the horses.

The digger shown in Plate XVIII, figure 1, is a modification of a 14-inch stubble plow. The moldboard is cut in half horizontally and the plow is equipped only with the lower part when digging large stock. For small stock a vertical wooden moldboard is used in place of the steel. This merely serves to push the trees away after they are loosened, but does not cover them.

With the digger shown in Plate XIX the principle of operation is very simple. A wedge-shaped knife 7 feet long, 12 inches wide, and 6 inches thick in the rear is drawn under the beds at regulated depths. As the trees are loosened they are crowded out over the wedge by the forward movement of the implement and are picked from the soil in the rear. The digger is drawn by a horse-operated capstan and steel cable and travels at the rate of 6 feet per minute. The trees are removed in perfect condition. It works better with transplants than with seedlings, because the latter are sometimes covered with soil before they can be removed.

All of these diggers loosen the soil to such an extent that the trees must be taken up very quickly; and since their economic rate of operation is considerably faster than transplanting, some extra labor is required to heel in the seedlings temporarily.

Precautions must be taken to prevent the drying out of the roots. It is well known to nurserymen that conifers are quite sensitive in this respect, but laborers do not generally realize its significance. In semiarid regions the danger is especially great. Buckets, basins, or tubs partially filled with water are sometimes kept at hand, and as fast as the seedlings are dug their roots are immersed in these. All the soil, and it is thought some of the fine rootlets, are washed off by this practice. This has led to a different method at some of the nurseries. Boxes about 3 feet long by 2 feet wide are padded inside with moist burlap or with burlap over moist sphagnum moss. They also contain, fastened at one end of the box, several moistened burlap pads which are used to separate successive layers of trees. As the seedlings are dug they are placed in the boxes in layers with a moist pad between each layer and carried to the transplanting area. In this manner the roots are kept constantly moist, but are not washed.

The importance of not subjecting the roots of conifers to exposure at any time can not be emphasized too strongly. Coniferous tops remain green for a long time after the roots are dead, and their appearance can not be taken as a criterion of the condition of the stock. An exposure of even 2 or 3 minutes, particularly on a windy or very hot day, may prove fatal; and mortality in transplant beds or in field planting may be due to lack of care in this respect rather than to improper methods of transplanting or field planting. At the Boulder Nursery experiments in exposing seedlings of Douglas fir to the sun for periods varying from 3 minutes to 4 hours resulted in a loss in the transplant beds of 5 per cent when the exposure was for 3 and 6 minutes, of 8 per cent with a 10-minute exposure, of 12 per cent with a 15-minute exposure, of 40 per cent with a 20-minute exposure, and of 90 per cent with a 4-hour exposure. While some stock survived even after 4 hours' exposure, it sustained in an increasing ratio a serious retardation in growth as the period of exposure increased.

### ROOT TRIMMING.

After being removed from the seed beds the roots of seedlings may be trimmed or pruned to a length of 6 or 7 inches before they are transplanted. A sharp knife, scissors, hatchet, or meat ax is suitable for the operation. Usually a bunch of seedlings are gathered in one hand and the roots of all pruned at the same time. In this operation special care should be taken to remove all badly skinned, broken, or diseased roots.

Root trimming facilitates transplanting operations, because the trenches do not have to be dug deeply to receive the seedlings; and to some extent it promotes the formation of a compact, well-developed root system. On the other hand, if it is carelessly done, the roots of some seedlings are likely to be cut so short as to injure them and cause greater losses in the transplant beds. Moreover, in digging seedlings for transplating it is seldom, unless special care is taken, that roots longer than from 8 to 10 inches are retained. These are not too long for rapid and successful transplanting. At the Boulder Nursery the conclusion has been reached that with Douglas fir root pruning makes the stock less desirable for planting on areas east of the Continental Divide, because it induces the formation of a root system too superficial for best results in planting in this dry region. In general, where the seed-bed operations are properly carried out root pruning is unnecessary.

### GRADING SEEDLINGS.

Seedlings which are badly damaged in digging and those which have very poor root systems or poorly developed tops should not be transplanted. Their use makes certain a greater loss in the transplant beds and the production of a mixed quality of transplant stock, some of which at the end of the regular rotation for the species is too poorly developed for field planting. Such seedlings should be discarded or, at most, transplanted in beds separate from the better stock. The discarding or grading can be done either when the seedlings are being removed from the seed beds or, better, as they are threaded into the transplant boards. In the latter case men with good judgment in this matter will have to be assigned to the threading tables. The importance of discarding or grading out such stock justifies the operation being practiced at all nurseries.

### TRANSPLANT TOOLS.

*Dibble.*—A dibble is a round or dagger-shaped, straight steel tool with a blade about 7 inches long and from ½ to 1 inch wide and usually provided with a handle. Its use is described later.

*Trenching tools.*—Spade: For opening the trench in the transplant bed to receive the seedlings the spade is most commonly used and is the best all-around tool for the purpose. With it, either a wedge-shaped trench or an excavation one side of which is vertical and the other sloping can be made. Moreover, it is better adapted to a variety of soils and for digging the trench to any desired depth than other tools.

Hand trencher: The hand trencher is described as follows in Volume X, No. 1, of the Forestry Quarterly:

> The hand trencher consists of two plates of steel 7 inches wide and 26 inches long, welded together along one edge and drawn out to a thin cutting blade. The opposite edges of these plates are separated about 1 inch, allowing space into which three pieces of ¾-inch pipe, slightly flattened, are inserted and riveted. One piece of pipe is inserted in the center and the other two at 2½ inches from the ends of the plates. All are brought together in a cross or four-way pipe connection, 8 inches above the plates. Into the upper opening of the cross a piece of pipe 20 inches long is fitted, supporting a toe into which 6-inch pieces of pipe are screwed forming a complete T-handle. To obviate a second bending of the pieces which extend from the ends of the blade to the handle, nipples and angle connections may be used. The trencher weighs from 18 to 24 pounds, depending on the thickness of steel used in the blade, and should be made by any blacksmith at a cost of from $3 to $5.
>
> To make a trench the trencher is put in proper position and weight put on it by placing the foot on the top of the blade. The operator then works the handle to and from his body as the blade sinks into the soil, making a trench about 2½ inches wide at the top and any desired depth depending upon the length of the roots of the seedlings to be transplanted. For a planting board 6 feet or 6 feet 3 inches long the trencher must be set into the bed three times in the same line. A 36-inch trencher requires two men to handle it while one man can handle a 26-inch implement. This tool leaves a trench with smooth sides and can be used very satisfactorily in almost any nursery soil.

This hand trencher was devised by Mr. William H. Mast for use at the Bessey Nursery, where the soil is very sandy, light, and easily worked. Here this tool has given very good satisfaction. It undoubtedly will do likewise in any other nursery where the soil is light, loose, and free of rocks and débris. It is also used successfully in the rather heavy soil of the Monument Nursery. There the tool used is only 12 inches wide and 8 inches high and has a wooden instead of a pipe handle. One very decided advantage which the trencher has is that the operation of opening up each trench in a bed packs the dirt firmly around the preceding transplanted row of seedlings and thus counteracts carelessness in this respect by the planter.

Broadax: The broadax has been used for trenching, but is unsatisfactory. The cleft style of trench only can be made with this tool and it is not so suitable for the purpose as the spade. It requires a more skilled operator, the depth of the trench is limited by the depth of the blade, and it is more difficult to run the lines straight.

Plow: Where the transplants are in long rows a plow has been tried for making the trenches and has worked admirably. The plow is of the small one-horse type and is equipped with an 8-inch (depth of trench) landslide, a short moldboard, and a shield to divert all the soil toward the moldboard side.

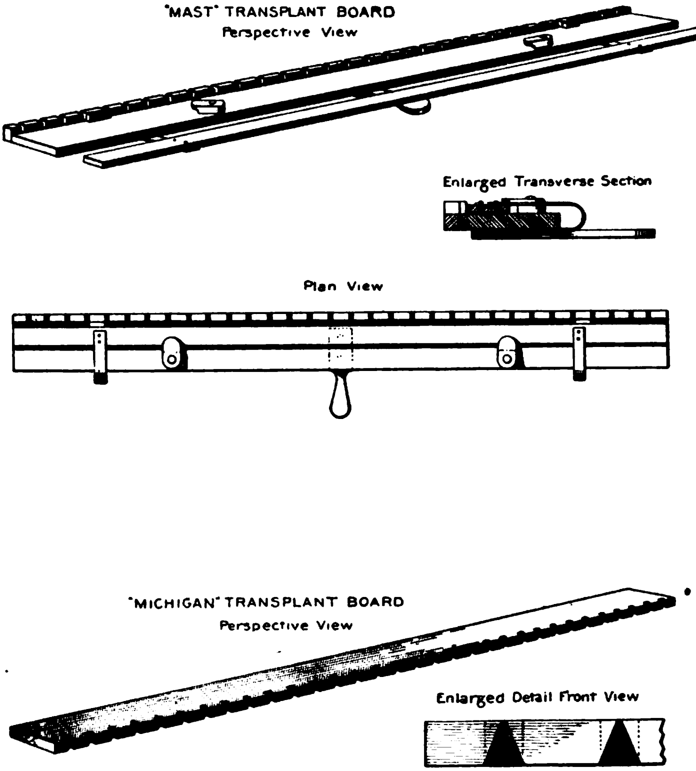

"MAST" TRANSPLANT BOARD
Perspective View
Enlarged Transverse Section
Plan View
"MICHIGAN" TRANSPLANT BOARD
Perspective View
Enlarged Detail Front View

FIG. 6.—Transplant board.

### TRANSPLANT BOARDS.

Transplant boards are all essentially the same in principle. There are two distinct types, the basis for the distinction being that in one, exemplified by the "Mast board," so called from its designer, Mr. William H. Mast, seedlings are threaded into the board from a bench and afterwards lowered into the trench; while in the other, exemplified by the "Michigan board," seedlings are threaded into the board as it lies on the ground projecting over the trench (fig. 6). With the first board a crew of from 5 to 7 men (2 planters, 1 or more trenchers, and 2 threaders) is usually employed; with the second board a crew of 2 men perform the operation.

The "Mast board" is described in Volume X, No. 1, of the Forestry Quarterly, as follows:

> The planting board consists of a 5-inch board 6 feet 3 inches long with a handle attached in the middle and extending in the same plane as the surface of the board. On the lower edge a piece 1½ inches wide is nailed flush with the back of the first board and its front edge beveled to about one-half inch in thickness. Into this edge 50 notches are sawed 1½ inches apart (when the trees are to be spaced 1½ inches apart in the transplant beds), one notch falling three-fourth of an inch from either end of the board. These notches are slightly wider at the bottom than double the saw-kerf, or about one-eighth of an inch, and should be made smooth with emery cloth or a sharp knife and rounded at the outer edge to admit of threading the trees into them easily. Before sawing the notches the parts between them should be strengthened by driving one or two 1¼-inch brads through them. The inner parts of the notches are flush with the face of the vertical board, so that when the trees are threaded into the notches they lie flat against the face of this 5-inch board. A slat placed over them and fastened by two buttons holds the seedlings in place while the board is being carried from the threading table to the trench. A loop or binding of tin over one end of the board forms a pocket into which the end of the slat is placed before being buttoned down; this helps to hold it and prevents it from slipping past the end of the board when placed on the trees. The slat fits loosely enough so that it does not crush the stems of the seedlings when it is buttoned down. The buttons are made with a slight bevel, so that when turned only partially over the slat they do not hold it so closely as when turned at right angles to it; this allows for handling both large and small stemmed seedlings with the same degree of efficiency.

At the Bessey Nursery the slat which holds the seedlings in place is now fastened to the transplant board by means of leather hinges. With this scheme the binding of tin over one end is unnecessary.

The "Michigan" planting board consists of a 6-inch board, 7 feet long and 1 inch or more in thickness, in which a row of one-fourth-inch holes are bored one-half inch from the edge at the interval of spacing desired in the transplant beds. A narrow, wedge-shaped slot is then cut from the edge into the hole and all rough edges and corners smoothed off. The point of the wedge is upward, so that any dirt that gets in the holes or slots may fall through without clogging and pulling out the seedlings when the board is removed. Before the slots are cut the edges of the board between them are reenforced with lath nails.

Both of these boards are efficient, but each has some advantage over the other. The "Michigan board" has been used most extensively at the Wind River Nursery and has been constructed there at a cost of 37 cents. The "Mast board" is more complex, but it also is quite easy of construction and has been made for 56 cents at the Bessey Nursery. The "Mast board" can be used with any sort of a trench; the "Michigan board" only with trenches which are constructed by excavating the soil. A single "Mast board" is better adapted for use with all sizes of seedlings, if they are of uniform development, than a single "Michigan board." With the "Mast board" the most efficient man for trenching, threading, and transplanting can be detailed to those duties, while with the "Michigan board" each man performs all of the operations. When the "Mast board" is used with seedlings which are not of even development, the smaller ones get displaced easily or lost out or, in the process of tamping the dirt around the roots, are pulled down too deeply into the trench. With both boards there is some danger of pulling the tops off the seedlings as they are released, but this is more pronounced with the "Michigan" than with the "Mast board." Under the greatest variety of conditions it seems that the "Mast board" is preferable to the "Michigan." Where the danger of drying out the roots of the seedlings is very great, the "Michigan board" should prove the better of the two. Using either board an efficient crew can average from 4,000 to 5,000 plants per day per man, and a record as high as 8,500 plants has been made at the Uinta Nursery with a board of the Mast type.

The "Yale board" is a modification of the Mast board, differing from it principally in that the slat which holds the seedlings in place is attached to the two hinged handles. The slat swings over to rest against the seedlings in much the same manner as when leather hinges are used with the "Mast board." The Yale type of board used at the Savenac Nursery is provided with spring clamps which press the slat against the seedlings and make knobs or buttons unnecessary. These clamps are conducive to greater speed in the transplanting operation. The two-men crews using these boards average 12,000 trees per man per day at this nursery.

Another board which is cheap, efficient, and used extensively is made simply by tacking a thin hardwood strip 2 or 3 inches wide on the flat undersurface of a 5 or 6 inch board, so that its edge will project about an inch beyond the edge of the wider board. In this projecting edge notches are cut to receive the seedlings. When threaded, the seedlings are held in place by means of strong elastic twine stretched in front of them from one end of the board to the other.

Planting boards are usually 6 feet long, to conform to the most common width of transplant beds. At the Converse Flats Nursery boards 8 feet long and at the Savenac Nursery boards 8½ feet long are used. At the latter nursery the rows run lengthwise, and the greater length of board is quite advantageous.

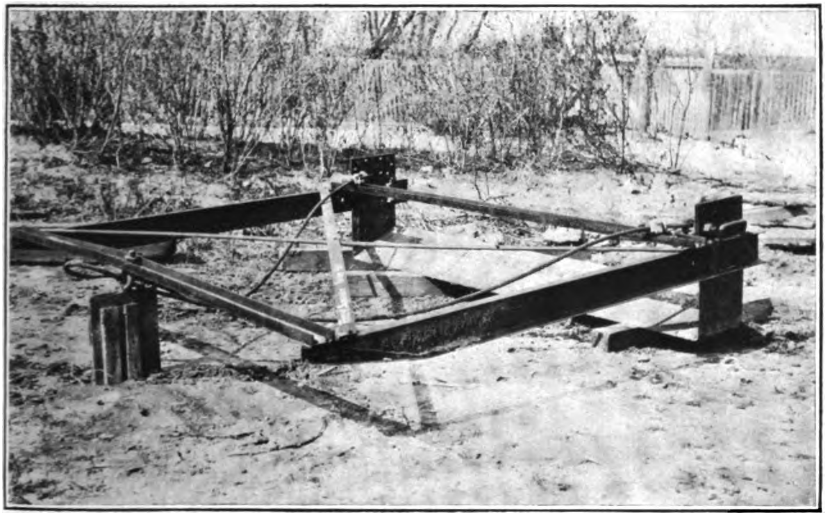


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FIG. 1.—TREE DIGGER IN USE AT BESSEY NURSERY.

Weight approximately 400 pounds.

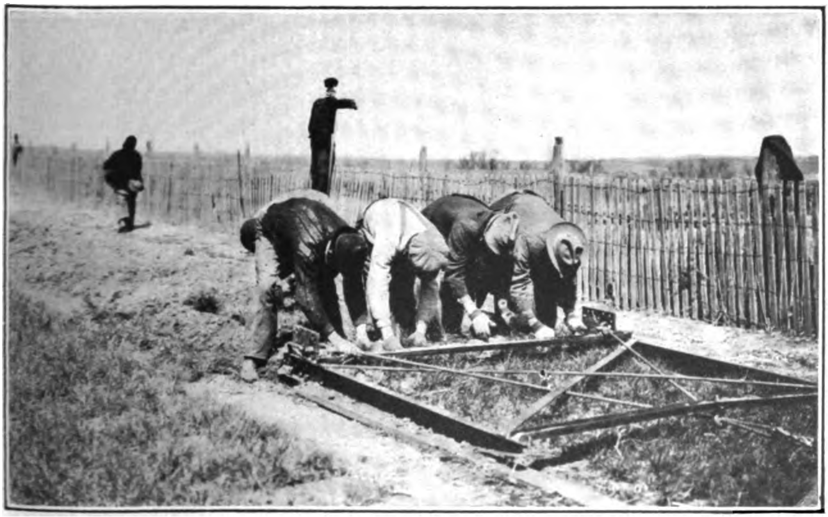

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FIG. 2.—TREE DIGGER IN ACTUAL OPERATION.

Four men are required to pick the loose trees from the soil as it breaks over the rear of the knife.

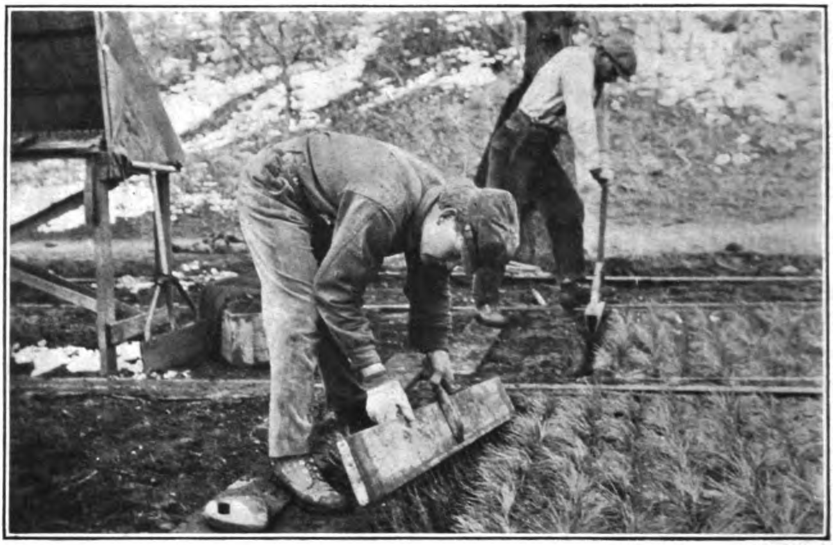

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FIG. 1.—OPENING TRENCH WITH HAND TRENCHER, LOWERING TRANSPLANT BOARD OF SEEDLINGS INTO TRENCH. THREADING TABLE AT THE LEFT.

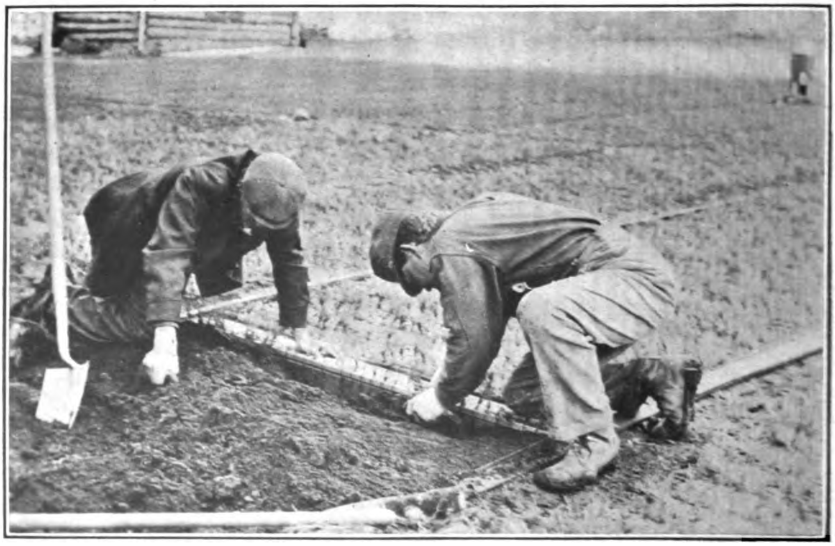

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FIG. 2.—TAMPING SOIL AROUND ROOTS OF SEEDLINGS.

TRANSPLANTING OPERATIONS.

### METHODS.

Transplanting methods in Forest Service nurseries are uniform to the extent that a transplanting board is used at all of them. Such boards have proved very efficient, rapid, and successful, even though very trying weather conditions prevail at the time of transplanting. The old method of using a dibble and transplanting each seedling as a distinct operation has been almost entirely discarded. It is accordingly only briefly described here.

*Dibble method.*—The operator inserts the dibble in the soil of the transplant bed and pries it back and forth or gives it a quarter turn to form an opening large enough to receive a seedling. The roots are then inserted in the hole and the dibble again thrust into the ground near the plant and pushed toward it to close the opening and pack the dirt around the roots. If the spacing in the transplant beds is close enough, this second thrust of the dibble can be made at the point where the next plant will be set and the operation of closing up the preceding cleft will at the same time open one for the receipt of the next plant. By the use of this system one man can transplant from 1,100 to 1,500 seedlings per day. It has proved a very inefficient method in that the size of the opening does not permit the roots to assume a normal position when the plant is inserted. Crooked, distorted roots and heavy losses in the transplant beds result.

*Transplant board method.*—Depth of trench: The trench should be deep enough so that the roots will not be curled up or bent over at their ends. Such a position is not conducive to the formation of good root systems. Roots bent unnaturally in this manner, moreover, are likely to break when the plants are dug or when planted in the field.

Setting seedlings in the soil: When the "Michigan board" is used the process of setting seedlings in the soil is quite simple. Laying the transplant board across the bed, a trench whose side next the board is vertical is excavated along its edge, each man of the 2-man crew covering half the distance. The seedlings are threaded into the holes, half by each man; the loose soil is then drawn in, a portion at a time, and packed against the roots until the trench is filled up level. To draw in and pack the soil against the roots a piece of inch board 6 inches wide by about 8 inches long is efficient. The transplant board is disengaged from the seedlings by a tilting forward and backward sliding movement.

The board is next placed with one of its edges flush with the row of seedlings just transplanted, another trench is dug along its other edge, and the operation repeated. A mark across one end of the board is kept in line with a heavy twine stretched along the edge of the bed, which is thus kept practically straight.

When a type of planting board like the "Mast board" is used, the process of transplanting is more complex in that the operation is performed by a larger crew, usually of five or more men, and each distinct part of the operation is performed by a portion of the crew assigned to it. In operations at the Bessey Nursery two men are employed in threading seedlings into each of the transplant boards, one man is employed in trenching with the hand trencher, and two men can do the planting. The threading is usually conducted on benches which are provided with canvas or burlap tops for shade and are placed as close as possible to the transplant beds. A shelter of some sort during threading operations is essential. The roots are kept moist by covering them with damp moss until placed in the boards and the threaders only strive to keep even with the planters. To have several threaded boards ahead of the planters means exposure and possible damage of the roots. It is quite generally maintained that the speed of transplanting depends upon the speed of the threaders; accordingly, men who are nimble with their fingers should be selected for this operation.

To expedite trenching, from 3 to 5 beds are carried forward at the same time. A trench is made in the first bed, then in the second, then in the third, and so on, the man making the trenches in each case being out of the way of the planters who follow closely behind him. The planters in their turn are out of his way when he returns to the first bed to make the next trench in it. A cord is stretched across the ends of the beds to be planted, so that the first row of each is in line with the first row in the others. The successive rows are kept equidistant by guide boards lying between each two beds on which lines are marked at intervals of 6 inches. Each trench is started in line with a mark on the board at one side of the bed and is finished at a corresponding mark on the board at the other side.

Two men can work together to advantage with planting boards 6 feet wide or wider. Upon receiving a board threaded with seedlings the planters face the trench and lower the roots into it with a slight swinging lateral movement to insure their assuming a natural hanging position. The soil in front of the board is then thoroughly tamped against the seedlings, the slat holding the seedlings in place is removed, the board rotated on its edge toward the planters, and the soil behind the seedlings also thoroughly tamped toward them (Pl. XX). By lifting the board now the seedlings are released and the operation is completed. Immediately after each day's transplanting operations are completed the beds should be thoroughly watered. Neglect of this operation has caused severe losses.

The size and disposition of the crew may be varied considerably to meet different conditions. Two men may be needed for trenching, particularly if the soil is not loose in character or if spades are used for the operation; and one man may be sufficient for planting. At the Savenac Nursery, where the trenches are prepared with a plow, two men, one a threader and the other a planter, comprise the crew. This is a matter to be determined during the course of the work.

*Pot method.*—Where field planting is of doubtful success because of extremely trying weather conditions, as in southern California, or where summer planting appears desirable, as in Arizona and New Mexico, the method of growing plants first in seedling flats and then transplanting them to paper pots has been tried. Both plants and pots are later set out in the field. The method of transplanting is simple. Paper pots 2 inches square by 8 or 10 inches deep are the preferable size if the plants are to be left in them for 1 year only. If they are to be left for 2 years a pot 3 inches square by 8 or 10 inches should be used. The transplanting is carried on under shade. Seedlings are removed one at a time from the flats and planted in the pots in the same manner that gardeners employ with vegetable or house plants. A hole is made with a dibble, the roots inserted, and the soil firmed around them. Watering follows the operation of transplanting.

This method of transplanting can be justified only where it is certain that only through it can stock be made to succeed under adverse field conditions, and further, that it is necessary to plant where such field conditions exist. Such transplanting is slow, one man being able to prepare soil and transplant only from 600 to 750 plants per day. The pots cost about $3 per thousand. Crates to hold the pots have been built for about 40 cents each. Until experience absolutely proves the superiority of such plants, this method of transplanting should not be practiced extensively. It has been given a trial both in California and Arizona nurseries. At the latter it has been abandoned because better results in planting have not been secured with the stock. At the former, indications are that such stock may prove the most successful.

### FACTORS AFFECTING COST.

A number of factors influence the cost of transplanting. Size of stock is one of these. The use of very small stock may materially increase the cost of the operation. Thus, at the Boulder Nursery in 1911 the cost of transplanting medium-sized stock, the preferable size, was $1.10 per thousand; small stock, $1.35; and large stock, $1.65. Large stock often necessitates wider spacing, which means the digging and filling of more trenches to accommodate the same number of seedlings, and small stock can not be handled rapidly. At the Fort Bayard Nursery the cost of transplanting western yellow pine with a spacing of 3 inches in the rows was in one case nearly 1.9 times and in another 1.5 times as much as where a 2-inch spacing was followed. At the Wind River Nursery the crews averaged 5,000, 3,800, and 3,300 trees per man per day when 1½, 2½, and 3 inch spacings in the row were used respectively.

On poorly prepared or heavy soils costs will be greater than on well prepared or loose soils. Thus, at the old Garden City Nursery, in a heavy soil, the crews averaged 3,000 plants per man per day, while in the near-by Kansas Nursery, whose soil is a pure sand, the average was 4,000 per man per day. The method followed in transplanting, whether by the dibble or by one of the various forms of transplant boards, will influence the cost. The character of the crew or crews will also be a factor. Good crews sometimes average from one-fourth to one-half more plants per day than poor ones.

### CARE OF TRANSPLANTS.

In the transplant beds the trees are given their final preparation for field planting, and the care given them has much to do with their success under field conditions. The root development can be controlled somewhat through watering, and this is the most important feature of transplant growth. Shading, cultivation, weeding, and care in winter need some attention.

*Watering.*—Immediately following transplanting, and for a period of 3 weeks thereafter, transplants should be watered liberally. During this period the plants should become pretty well established and start growth. Watering can then be decreased, but for the greater part of the growing season the soil should be kept fresh within a short distance of the surface. At the Monument Nursery western yellow pine at first requires more water than either Engelmann spruce or Douglas fir, but later the opposite is true. Because the roots are confined to a small amount of soil, potted transplants must be watered more frequently than those in beds.

It has been pretty well proved that in a soil which is kept fresh near the surface there will be a good lateral development of the roots in this zone, and that such stock is in the majority of cases more suitable for field planting than if the greatest development of the root system occurs at the lower end. In digging transplants for transferring to the field the lower portion of the roots is almost certain to be cut or broken off. The result is that when a plant whose main root development has been at the lower end is placed in its new habitat, it must develop new feeders before it can fully avail itself of the water and plant food available. It is desirable, therefore, that the main development be kept within the first 8 to 10 inches of depth, and watering should be conducted with that end in view. By keeping the soil of the transplant beds fresh near the surface, western yellow-pine stock is now being produced in Arizona, which succeeds when planted even under the arid conditions obtaining in that country during the spring of the year. This success is a good criterion of the stock's merit, particularly as very poor results had previously been obtained from field planting with the ordinary run of stock without pronounced lateral roots developed near the surface. Little or no watering for the purpose of hardening the trees to the conditions which obtain in the field has not yet, in Forest Service operations, produced more successful stock for field planting than well-watered stock. At the Bessey Nursery, in fact, much better results have been secured in field planting with stock which was watered in accordance with the regular nursery operations than with that which was not watered at all.

Any of the methods of watering applicable for seed beds may be used, but sprinkling by hand with a hose is expensive and scarcely practicable. Irrigation or the use of garden sprinklers is almost essential. Because of the large size of the transplants, irrigation is much more feasible than in seed beds, and because of its rapidity it is a method which should always be given consideration. At the Bessey Nursery, where flooding is practiced, the transplant area is watered in sections. Areas of one or more beds are banked up with soil around the edge, and water is then conveyed to them from the 4-inch main pipe line through large canvas irrigating hose. When one section becomes flooded the hose is moved to the next one. One acre can be covered in six hours. At the Savenac Nursery, where ditch irrigation is used, the water is controlled, as in agricultural projects, by a system of headgates and by temporary mud dams for diverting it from one ditch to another (Pl. XXI). On steep grades some wooden troughs, with small holes bored through at intervals to allow the water to escape to the ditches, are employed. It is claimed that one man can water 3 acres per day. Ditch irrigation is practiced also at the Fort Bayard Nursery. There a system of galvanized-iron troughs to carry the main body of water is being tried. Opposite each ditch in the transplant area these troughs have openings the size of which can be regulated by means of a sliding cap. The amount of water turned into each ditch can be controlled easily and absolutely.

A single watering by any method should be thorough enough to soak the soil to a depth of about a foot. Experience indicates that it may ordinarily be conducted at any time of the day without injury to the plants, except at the Pilgrim Creek Nursery, where sprinkling is practiced, and where it seems to be necessary to water bigtree (*Sequoia washingtoniana*) in the evening rather than in the morning.

*Shading.*—Shading is almost wholy unnecessary in transplant beds, except in a few cases; and because of the expense involved, if for no other reason, it is decidedly undesirable. If plans will permit it, species should not be grown at a nursery where it is necessary to give them shade during the transplant stage. Some trees, however, such as spruce, true firs, redwood, and western red cedar, have, wherever grown so far, appeared to need shade when first transplanted. Douglas fir transplanted when only 1 year old has shown a need for shade at the Beaver Creek Nursery in Utah, at the Pocatello Nursery in Idaho, and at the Gallinas Nursery in New Mexico. Engelmann spruce transplants do better if shaded, both at the Monument and Wind River Nurseries; and the same is true of western red cedar at Wind River.

Shading of transplants is expensive. It stimulates height growth, which is normally undesirable in stock for field planting, and the stock produced is not so well fitted for enduring the more trying conditions to be met in the field as that grown in full sunlight. A possible exception to this is to be found in the case of Douglas fir for planting under aspen in Utah and southern Idaho. Here it is thought, but not proved, that stock shaded in the transplant beds may be preferable for field planting.

*Cultivation and weeding.*—Cultivation serves the same purpose in transplant beds as in seed beds; that is, it breaks up a crusted surface soil, conserves soil moisture, and cuts down the amount of weeding and watering necessary. At the old Garden City Nursery only one-third as much watering was necessary with cultivation as without it. Cultivation is best carried on as soon after watering as a crust begins to form on the soil, and it is a particularly desirable operation in heavy soils. On loose, sandy soils it is not so essential, but is beneficial even there. It can be carried on rapidly with a wheel cultivator, by the use of an ordinary potato hook whose center tine is cut out, or by some other similar tool which straddles the rows (Pl. XXII).

Weeding should be done as often as is necessary, which is usually from three to four times a season. Pulling by hand is the most effective method, but some implements are good, such as narrow hoes or tools with sharp V-shaped edges. At the Wind River Nursery the chief weeds are brake fern and blackberry vines, which can not be pulled very well without damaging the trees. They are accordingly cut off below the ground. For this purpose a weed cutter was originated from one of the straps of steel which reinforced the shank of the handle of a worn-out shovel. This short, half-tubular, curved piece of steel with a sharp V-shaped notch filed in the end of it was riveted to the end of a broom handle. Experience has shown that this tool is very well adapted to the work.

*Mulching during winter.*—Transplants in general need no attention during the winter. Occasionally mulching is practiced when there is the possibility of heaving or of winterkilling, but after a season's growth in the transplant beds the stock is usually so well rooted that there is little danger from the former source. This is particularly true in nurseries of sandy soils and in those where the snowfall comes early and is abundant and stays until fairly late in the spring. If artificial mulches are necessary, the same ones may be used as in the seed beds. At the Gallinas, Monument, and Converse Flats Nurseries mulching of transplant beds over winter is necessary.

At the Monument Nursery a light covering of straw held in place by oak brush is sufficient for western yellow pine. For Douglas fir the space between the trees is filled with leaf mulch, after which a layer of lath slatting is rolled over the beds to bend down the long shoots. This is covered with a thin coat of leaf mulch, which is held in place by oak brush. Engelmann spruce is covered with leaf mulch, which is held in place by brush. Heavy winter winds make mulching necessary at this nursery. At the Converse Flats Nursery mulching is necessary to prevent heaving, because fall transplanting is practiced. Pine needles are distributed between the rows to a depth of about 3 inches.

*Heights, in inches, of different classes of nursery stock.*

| Region and species. | Class of stock. | | | | | |
|---|---|---|---|---|---|---|
| | 1-0[1] | 1-1 | 1-2 | 2-0 | 2-1 | 2-2 |
| | *Inches.* | *Inches.* | *Inches.* | *Inches.* | *Inches.* | *Inches.* |
| Rocky Mountain: | | | | | | |
| Pseudotsuga taxifolia | 1 to 2 | | 4 | 2 to 5 | 2½ to 6 | 5 to 6½ |
| Larix occidentalis | 1 to 1½ | 2 to 5 | | | | |
| Pinus divaricata | 1 to 3 | 5 | 15 | 5 | 10 | |
| Pinus jeffreyi | 1½ to 3 | | | 2 to 5 | | |
| Pinus monticola | 1 to 1½ | | 4 | | | 6 |
| Pinus ponderosa | 1 to 3 | 2 to 4 | 5 to 16 | 2 to 8 | 4 to 10 | 9½ |
| Picea engelmanni | ½ to ¾ | | 4 | 1 to 1½ | 2½ to 3 | 4 |
| Pacific Coast: | | | | | | |
| Pseudotsuga taxifolia | ½ to 5 | 4 to 9 | | 6 to 10 | | |
| Abies nobilis | 2 | 2 to 4 | | | | 6 to 10 |
| Abies concolor | ½ to 2 | 2 to 6 | | 6 to 8 | | |
| Larix occidentalis | 1 | | | 2 to 8 | | |
| Pinus jeffreyi | 2 to 4 | 4 to 7 | 6 to 8 | 5 to 6 | | |
| Pinus monticola | 1½ to 2 | 1½ to 3 | | 2 to 4 | | |
| Pinus ponderosa | 2 to 4 | 2 to 8 | 6 to 12 | 5 | 4 to 7 | |
| Libocedrus decurrens | 2 to 3 | | 9 | | | |

[1] The first figure of each pair indicates number of years stock remains in seedbed; second figure, the number of years in transplant beds.

LOSS IN TRANSPLANT BEDS.

Losses in transplant beds should not exceed from 5 to 10 per cent. They are often greater, but they can be reduced to a minimum by careful transplanting, the choice of stock of the right age and size for transplanting, grading, care in taking up the plants so as not to injure the roots, keeping the roots constantly moist, reducing the time between lifting and transplanting, little or no root trimming, soaking the beds thoroughly immediately after transplanting, and by conducting the operation as early in the spring as the weather will permit. Losses will unquestionably be greater with some species than with others. Thus sugar pine and Arizona cypress have been found to be difficult trees to transplant without rather severe losses.

## REMOVAL OF PLANTING STOCK FROM NURSERY.

### DIGGING.

As far as possible, stock for shipping should be taken up as packing progresses. The transplants are dug with a spade or horse-drawn tree diggers in the same manner as seedlings. The number which can be dug in a day depends upon the method, the size of the stock, the character of its root system, the nature of the soil, the weather, and the spacing. At the Wind River Nursery, where the soil is fairly loose and the spacing 1 to 1½ by 6 inches, 2 men have dug 1–1 Douglas fir at the rate of 40,000 per day. This number is large, and as speed is conducive to carelessness the maintenance of such a rate should not be attempted. An average of 15,000 per day for 2 men digging only should be easily possible, making the cost of the operation about 25 cents per thousand. Where grading and counting are practiced in conjunction with digging, the rate is decreased. With horse-drawn tree diggers the rate can be increased one-half or more. As the trees are removed they can be heeled in right back of the diggers and afterwards counted, graded, and bunched under cover of a building, or these operations may be performed by an additional man as fast as the trees are lifted. The bunches of each class of stock should be uniform in shape and size and not too large, and should contain equal numbers of plants, ordinarily from 25 of the larger to 150 of the smaller trees. These bunches are tied loosely, and then heeled in if packing is not being carried on at the same time. If the weather is very dry while counting is in progress, the roots should be sheltered and immediately covered with damp soil, burlap, or moss as soon as they are bundled.

### GRADING.

Grading stock requires about twice as much time as when extra plants are included to make up for the average number of culls per bunch. The time saved by this latter method may be worth decidedly more than the value of the extra trees which might be included in a shipment through error in overestimating the number of culls. One man can count, bundle, and tie on an average about 12,000 trees per day, making the cost approximately 21 cents per thousand. Where close grading is considered essential, as in Arizona and New Mexico, it can be conducted more effectively at a nursery than by a planting crew, and the culls should accordingly be discarded before shipping. Where close grading is not considered necessary, as in the Pacific Northwest, strict counting of the stock as it is dug may not be essential. At the Wind River Nursery the practice is followed of estimating closely the stock in each transplant bed and supplying definite amounts for shipment from these estimates. This practice has been largely responsible for reducing the cost of distribution from $1.31 to $0.855 per thousand.

### PACKING.

The general practice in Forest Service nurseries is to tie the trees in small bunches. In this shape they are easier to handle both at the nursery and at the planting site, and it has been thought that they withstand better the rough treatment incident to shipping and to packing on horses. That this bunching is unnecessary is shown by experience at the Monument Nursery. Here packing is conducted in the usual manner, except that the trees are spread out in thin successive layers. Moss can better come in contact with all roots than where the trees are bunched, and trees packed thus have withstood shipment for long distances and arrived in good condition.

The main points to be given consideration in packing for shipment are to minimize the possibility of the roots drying out and the tops heating while en route. To avoid this, the plants are shipped in open crate-like boxes which provide ample ventilation for the tops; and damp moss, preferably sphagnum because it holds moisture best, is packed around the roots. At the Savenac Nursery, the sawdust from a shingle mill has been found very satisfactory for packing. Trees are usually placed in the crates in tiers, the tops of one tier toward one end of the box and the tops of the next tier toward the opposite end, the roots of the successive layers overlapping. A strip of moist burlap as wide as the space covered by the roots of the plants should be spread in the bottom and extend up along the center of both sides of the crate. On this a layer of damp, well-drained moss is placed and then the first tier of transplants. Another layer of moss is now placed over these roots and chinked in between them, but none is placed upon the foliage of the trees. Then another tier of trees is placed on the moss, and the process continued until the crate is filled. Care must be taken not to pack the crowns too tightly or to get them wet, as either may induce heating. If the roots are packed as firmly as they should be, the tops may be too tightly together. To overcome this difficulty it is sometimes desirable to place moist strips of burlap among the roots next to the moss. This will enlarge the space that they would naturally occupy and serve to keep the crowns farther apart. When the crate is filled, moss should be placed upon and damp burlap stretched over the roots of the top tier, and the top of the crate nailed on. When ready for shipment, the trees should be packed solidly enough so that they will not jar or shake around. If they are to undergo especially trying conditions while en route, each separate bundle may be bound in damp moss and this wrapped with a layer of damp burlap. Trees packed in ways very similar to this have been shipped from California to Hawaii, and have been on the road for a month, yet arrived at their destination in perfect condition. Packing should be intrusted only to careful and conscientious men who can be supervised or who have had previous experience. Cured moss is very likely to heat when packed closely and thus burn the roots of the planting stock and kill or seriously injure it.

### PACKING CRATES.

The general type of packing box in use at Forest Service nurseries has a solid bottom and ends of seven-eighths-inch material and sides and top of three-eighth-inch slatting. At the Fort Bayard Nursery both ends and sides are made of lath slatting. At the Monument and Bessey Nurseries the lath slatting formerly used on high shade frames is used in one continuous strip for bottom, sides, and top of the crates. In assembling crates, it has been found at the Pilgrim Creek Nursery that cement-covered box nails hold better than others. The essential point about packing crates is that they be cheap, light, strong, easily assembled, well ventilated, and of a size suitable for packing on a horse, which means that when filled they should not weigh over 75 or 100 pounds.

For local shipments the Monument Nursery has adopted woven wire, cylindrical crates of two sizes, one 2 feet 6 inches in diameter by 1 foot 6 inches deep and another 2 feet in diameter by 2 feet deep (Pl. II). One end of the cylinder is removable to permit packing. The stock is packed with the tops to the outside and the roots to the center around a strong iron rod which runs longitudinally up through the center of the crate. When filled, the top is put on and clamped in place by means of a washer and nut on the end of the rod as it projects through the top. This crate has some advantages over wooden ones. It is exceedingly strong, the trees can be packed more rapidly, in better shape, with less moss, and much more cheaply than with the other style of crate, and ventilation of the tops is about perfect. On the other hand, those in use cost $7 each and are very heavy, which makes the cost of shipping and their return high; and they require considerable space for storage.

Packing boxes of spruce 24 inches long by 14 inches wide by 15 inches deep cost the Wind River Nursery 29 cents each knocked down, and about 5 cents each to assemble at the nursery. Boxes of this size fit nicely into an ordinary wagon box, weigh approximately 75 pounds when filled, and are a convenient size for packing on a horse.

At the Cottonwood Nursery boxes or crates 12 inches by 14 inches by 2½ or 3 feet are used. The 3-foot size will hold 20,000 2–0 Douglas fir, 7,500 2–1 Douglas fir, 10,000 1–0 yellow pine, or 6,250 1–1 yellow pine; the 2-foot size will hold 20 per cent less. A 16 by 16 by 24 inch crate at the Pilgrim Creek Nursery holds 800 1–2 western yellow pine, 1,000 1–1 bigtree, 1,250 1–1 western yellow pine, or 1,500 1–2 sugar pine or 1–1 incense cedar.

At the Savenac Nursery the trees are rolled in a strip of burlap for shipping. The device for making the rolls is somewhat on the order of a shingle-weaving machine. Two 6-foot lengths of lath yarn fastened by means of poultry netting staples to two wooden cleats (the cleats 18 inches apart and the two lengths of lath yarn 12 inches apart) 2 feet long are first placed in the bottom of the packer. A strip of burlap 6 feet long and 21 inches wide is placed over the lath yarn and cleats, and over the burlap is laid a 6-foot sheet of 18-inch "butcher's" wrapping paper. The bunches of trees, after being moderately root pruned, are then laid in the packer in two tiers, roots to the center, each layer being well packed in wet shingle tow. When the container is full, the ends of paper and burlap are drawn together at the top and the ends of the burlap are wrapped around a good hard strip of wood (tamarack 1 inch by 2 inches by 2 feet). The ends of this stick extends about 2 inches beyond the edges of the burlap. On these uncovered ends a grip is secured by means of a long tool—16 inches—similar to a wagon hammer. With this purchase the burlap can be twisted as tight as its tearing resistance will permit. When the burlap has been drawn tight this wrenching tool is held in position by means of a catch on the packer and the hands are free to tie the bundle with the lath yarn. This completes the operation. The front side of the packer is let down and the bundle taken out (Pls. XXI and XXII). The burlap strips are saved in the field and at the close of the season shipped back to the nursery.

Aside from a considerable lowering of the cost, a number of other advantages are claimed for this method; the number of trees per bundle can be varied; one man can pack approximately one-half million trees per day; the bundles are easy to handle; they will not break when thrown around; and they make a better pack for pack horses.

In these bundles the trees stand transportation well and they do not heat or dry out readily. Packed in this manner, they have been left in a warm place for 6 days and were cool and moist when the bundle was opened.

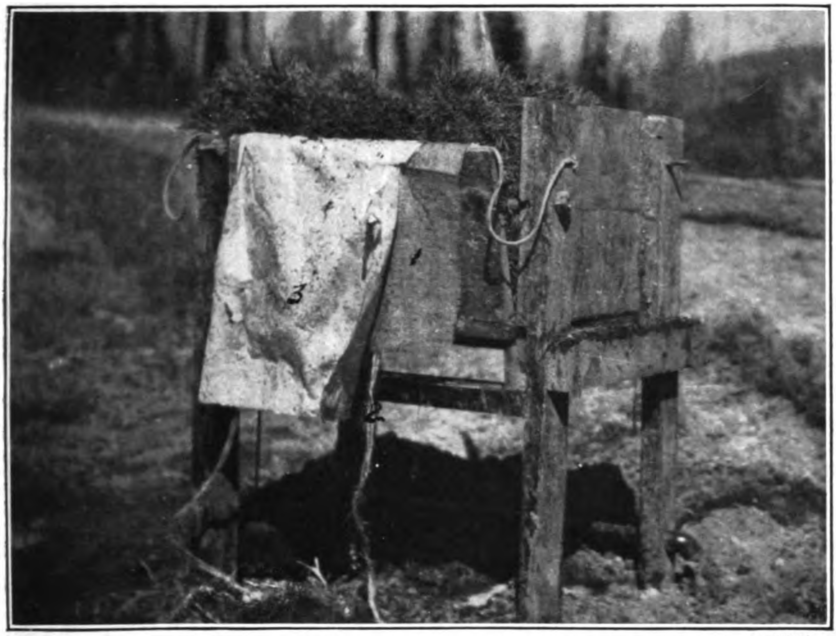
### SHIPPING.

Because of the danger which accompanies delays en route of growth starting, of drying out, of heating, or of holding up planting operations, shipments of nursery stock should preferably be by express; or, if the packages are small, by mail. Shipments by freight are much cheaper, and for distances up to 300 miles have proved very satisfactory in California. Special arrangements can sometimes be made with freight agents to put a shipment through promptly, but the risk is greater than with express shipments. Shipments are liable to be delayed under the best of conditions, because express or railroad officers do not always realize the necessity of prompt delivery. To avoid this, it is believed best for the shipper to indicate plainly on the outside of each crate that the contents are "perishable," that they contain "live plants" the "prompt delivery" of which is "necessary," or some similar phrase. Night shipments are preferable to day shipments.

## DISEASES AND INJURIES IN NURSERY.

### DAMPING-OFF.

Damping-off is a source of great danger to young seedlings. This disease is most commonly caused by one of three fungi, *Pythium bebaryanum* Hesse, *Rhizoctonia* sp., and *Fusarium* sp., and its presence in a bed is indicated in a very characteristic manner. The stems of seedlings attacked exhibit a rather dirty, watery, or rotten appearance at the surface of the ground and for a quarter of an inch or more upward. The stems become flaccid and limp in this section, and the seedlings topple over unless they are held up by surrounding plants. There is no recovery. Seedlings are most susceptible to danger from this source during a period of from 2 to 6 weeks following germination, and some species are more susceptible than others. The seedling may even be attacked before it appears above the ground.



F-26332A

FIG. 1.—TREES IN PLACE READY FOR BINDING.

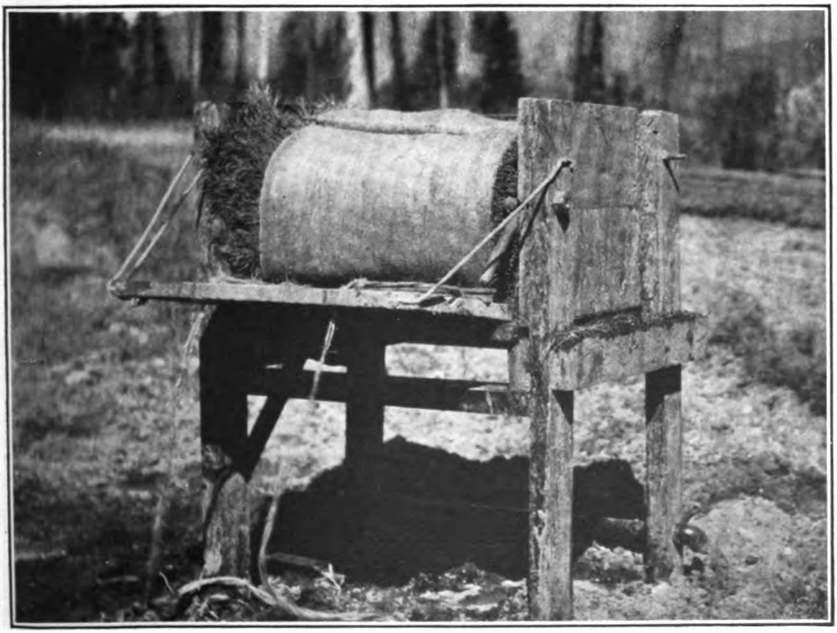


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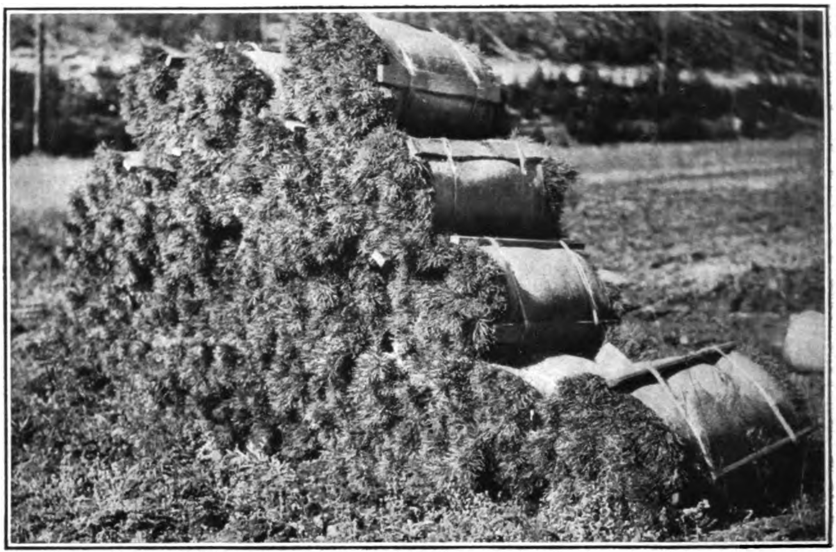
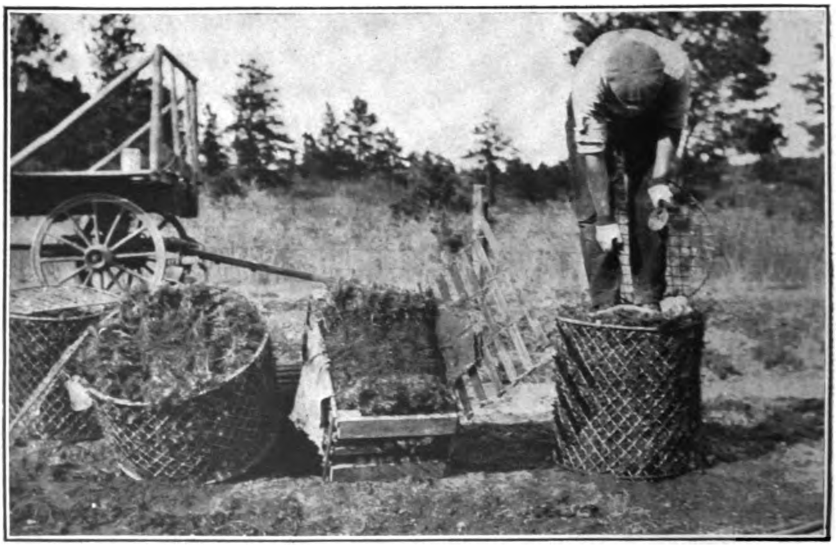
FIG. 2.—BUNDLE TIGHTENED AND READY FOR TYING.



F—[illegible]A

FIG. 1.—TYPE OF PACKING CRATE IN USE AT WIND RIVER NURSERY.

Fifty thousand western white pine packed for shipment, Savenac Nursery.



F—6—ORT

FIG. 2.—TYPES OF SHIPPING CRATES USED AT MONUMENT NURSERY—WOODEN FOR SHIPPING LONG DISTANCES, WIRE FOR SHORT DISTANCES.

***Susceptibility of species to damping-off in Forest Service nurseries.***

| Nursery. | Species. | |
|---|---|---|
| | Most susceptible. | Least susceptible. |
| Savenac | Pinus ponderosa [1]<br>Pinus strobus [1]<br>Pinus monticola [1] | Pseudotsuga taxifolia.<br>Larix occidentalis.<br>Picea engelmanni. |
| Boulder [2] | Pinus sylvestris<br>Pseudotsuga taxifolia<br>Pinus ponderosa | Pinus austriaca. |
| Trapper Creek | Pinus monticola | Pinus ponderosa.[3] |
| Monument | Pinus austriaca<br>Pinus ponderosa | Pseudotsuga taxifolia.<br>Picea engelmanni. |
| Bessey | Pinus resinosa<br>Pinus divaricata | Pinus austriaca.<br>Pinus sylvestris.<br>Pinus ponderosa. |
| Fort Bayard | Pinus attenuata<br>Pinus sylvestris | Pinus ponderosa.<br>Pinus jeffreyi.<br>Juniperus monosperma.[4]<br>Juniperus pachyphloea.[4]<br>Cupressus arizonica.[4]<br>Pinus edulis.[4] |
| Cottonwood | Picea engelmanni<br>Pseudotsuga taxifolia [1] | Pinus monticola.[4]<br>Pinus ponderosa.[4]<br>Pinus contorta.[4] |
| Beaver Creek | | Pinus ponderosa.[4]<br>Pinus contorta. |
| Pocatello | Pseudotsuga taxifolia | Pinus sylvestris.[3]<br>Pinus austriaca.<br>Pinus ponderosa.[1] |
| Pilgrim Creek | Pseudotsuga taxifolia [1]<br>Sequoia washingtoniana [1]<br>Pinus jeffreyi.[1]<br>Pinus sylvestris.[1] | Pinus ponderosa.[4]<br>Libocedrus decurrens.[4] |
| Converse Flats | Pinus ponderosa [1]<br>Pinus jeffreyi [1] | Libocedrus decurrens.[1]<br>Cedrus deodara.[1] |
| Wind River | Pseudotsuga taxifolia [1]<br>Larix occidentalis [1] | Pinus monticola.[1]<br>Pinus ponderosa.[1]<br>Abies nobilis.[1] |
| Page Creek | Pinus lambertiana | Pseudotsuga taxifolia.[1]<br>Pinus ponderosa.[1]<br>Chamaecyparis lawsonia.[1] |

[1] Damping-off not serious.
[2] Attack not serious except with fall-sown western yellow pine and Douglas fir.
[3] Worse in fall-sown than in spring-sown beds.
[4] Not affected by damping-off.

At nearly all Forest Service nurseries damping-off has not been particularly virulent, whether because of properties of the soil or not is unknown. When it has appeared, the most general method practiced for its control has been simply to expose the beds to full sunlight and, where practicable, to stir the surface soil. The spread of the fungi is promoted by damp, warm soil and weather, although *Rhizoctonia* and *Pythium* attack seedlings even in rather cool, damp weather. The effect both of exposing the soil to the sun's rays and of stirring or cultivating it is to dry it out and thus produce a condition unfavorable to the further development and spread of the fungi.

An effective method of control has been worked out by Hartley[1] and Pierce at a number of nurseries. At the Bessey Nursery, where damping-off has at times been very serious, commercial sulphuric acid is applied to the beds immediately after the seeds are sown and covered at the rate of three-sixteenths of a fluid ounce in solution with 1 quart of water to the square foot of seed-bed surface. This acid applied at the rate designated has been found very efficient. When acid is used seed beds must be kept well moistened during the germination period. Neglect of this results in concentration of the acid in the surface soil through capillary rise of the solution, and the growing apex of the radicles of the germinating seed are killed, which may result in the death of the plants. For some other nurseries different amounts of acid were found successful; at a good many places it was found unnecessary to take any special precautions in the way of extra watering in the acid-treated beds. The results obtained from this treatment are in accord with what has been found true elsewhere, that damping-off is much less prevalent in soils of an acid than in those of a weakly alkaline reaction. Experiments at the Vermont Agricultural Experiment Station[1] indicate that damping-off is likely to be less serious in beds to which there has been applied a well-rotted compost of horse manure and muck. Such an application will undoubtedly tend to make the soil more acidic in its nature and thus antagonistic to the development of the fungus.

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[1] Hartley, Carl, and Pierce, Ray G. "Control of Damping-off of Coniferous Seedlings." U. S. D. A. Bul. No. 453.

In addition to checking damping-off effectively, acid treatment at the Bessey Nursery has resulted in the production of stock that averages fully an inch higher than nonacid-treated stock. At this nursery another feature of the acid treatment is that it seems to kill the weed seed and very greatly reduces the cost of weeding thereby. During 1912 the cost of weeding acid beds was $0.0044, while the cost of non-treated beds was $0.0125 per square foot.[2] The extra cost of acid treatment was $0.005 per square foot. The total cost of acid and weeding was therefore $0.0094 per square foot, as compared to $0.0125 for weeding only of nontreated beds. Thus the saving in the cost of weeding at least fully offsets the increase in cost due to acid treatment.

A 1 per cent formaldehyde solution applied at the rate of three-fourths of a gallon per square foot about a week before the seed is sown has been shown[1] to be very effective in preventing damping-off, but it is known that formaldehyde may kill seed which is still dormant. On the whole, the experience with formaldehyde at most Forest Service nurseries has not been as satisfactory as with acid. The formaldehyde, especially with sandy soils, must be applied two or three weeks before seed are sown in order to avoid killing them.

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[1] Gifford, C. M. "The Damping-off of Coniferous Seedlings." Vt. Agr. Exp. Sta. Bul. 157.

[2] Cost of acid treatment will be temporarily higher during the European war on account of increased price of acid.

However, it has the advantage of never making necessary special watering after the seed are sown.

At the Monument Nursery hot dry soil sprinkled over and worked into the soil of an affected area has proved quite effective in checking damping-off.

Sowing at certain seasons as a preventive of damping-off is indicated by the experience of some nurseries. Western yellow pine and Douglas fir at the Boulder, western yellow pine at the Savenac, and Douglas fir at the Wind River suffer the most severe losses, and jack pine at the Bessey Nursery suffers least, when the sowing is done in the fall.

### WINTER MOLDING.

A type of injury which has proved serious only at the Cottonwood Nursery is due to molding. Molding is caused by heavy accumulations of snowfall remaining on the nursery area longer in the spring than normal. When the snow goes off the plants are found pressed down flat upon the ground, with foliage brown or black and moldy. In some cases the stems remain green and the plants recover, but usually the plants succumb entirely. Norway, Engelmann, and blue spruce have never suffered very heavily, particularly after the stock has passed its first year. Douglas fir is the worst affected species and suffers most in 1–0 and 2–0 stock. Western yellow pine has never been much affected as seedling stock, but losses have occurred in the 1–2 transplant beds. No effective preventive is known for this at present. Douglas fir suffers less severely in drill-sown than in broadcast-sown seed beds.

### WIND INJURY.

Wind may whip, break, and dry up plants, or in loose soils drift the soil over them. Windbreaks of some bushy shrub or tree or of artificial construction are the most efficient remedy.

### SUMMER DROUGHT INJURY.

Summer drought injury[1] is a physiological trouble rather than one due to fungi. It is caused by an insufficient amount of water or shade; is evidenced by the dying of the roots, a yellowing or browning of the tops, and the final death of the plants and is most usual during the hot, dry months of summer. It has often been called simply blight and, until recent investigations by Mr. Hartley, was thought to be due to fungi. Summer drought injury has caused considerable damage at the Bessey Nursery and is more likely to be a source of danger at a nursery where the soil is loose and subject to very rapid drying out than at one with a heavier, more retentive soil. It is also likely to be more serious with shade and moisture loving species, such as spruce and western red cedar, than with such drought-resistant species as western yellow pine. As the absorbing portions of the roots die at the same time or even just preceding the time of yellowing of the leaves, it is important that the trees never be allowed to reach this stage. Recovery is then doubtful. The remedy is obvious. Excessive crowding in seed or transplant beds should be avoided; the soil should be kept fresh at all times after the damping-off period has passed; exceptionally heavy watering should be practiced during periods of particularly drying or hot weather; and shade should be supplied if necessary.

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[1] For full discussion, see Bulletin of the United States Department of Agriculture No. 44, "The Blight of Coniferous Nursery Stock," by Carl Hartley, of the Bureau of Plant Industry.

A type of injury similar to summer drought injury but rather uncommon may be caused by an excess of water. This makes itself evident by the yellowing and final death of the plants. Recovery from this is claimed to be slower and even more doubtful than from sun scorch.

### WINTERKILLING.[1]

Winterkilling produces a condition in plants very similar to that of sun scorch and physiologically is due to the same cause; that is, the inability of the roots to furnish moisture to the tops as fast as it is lost by transpiration during periods of severe, trying weather. Winterkilling differs from sun scorch, however, in that it occurs during the winter, and it is not necessarily due to insufficient water in the soil but rather to the fact that the water is frozen and thus not available to the plant. Periods of strong winds or of bright, warm days during the winter when the ground is frozen are most likely to cause winterkilling. Sometimes only a portion of the top of the plants is injured. This is especially likely to occur with any portion which protrudes above a snow covering. Mulching is the preventive for this type of injury.

### FROSTS.

Losses from killing frosts are infrequent but usually extensive when they do take place. This is due to the relatively few species growing in any one nursery and the large number of plants which happen to be in the same class and in a like susceptible condition. If seed is obtained in localities which have a climate similar to that of the nurseries, if it is sown so as to give the trees the benefit of the full growing season, and if growth is not stimulated too late in summer through watering and cultivating, no further measures are required to prevent frost-killing under normal conditions. But additional safeguards are necessary to prevent losses resulting from unusual conditions.

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[1] For full discussion, see Bulletin of the United States Department of Agriculture No. 44, "The Blight of Coniferous Nursery Stock," by Carl Hartley, of the Bureau of Plant Industry.

In cases where the slope of the ground permits and where a supply of water is available, heavy flooding of the beds will prevent frost damage. The temperature of the water is usually above that of the air and it does not cool so rapidly. A considerable quantity of wild meadow hay spread over the beds will prevent frost injury as well as rapid thawing in case freezing has already taken place. The method followed in orchards of building a smudge may be used. Either wood or hay will serve the purpose, and small piles will have to be distributed in the paths throughout the nursery. Emphasis must be laid upon the need of anticipating the danger, of preparing for it, and taking action when the danger is most imminent. Heavy frosts can generally be foreseen the evening before and the local Weather Bureau can doubtless notify the man in charge when there is any real danger. Thermostat alarms may also be provided. If proper precautions are taken, wholesale losses can be prevented even though the plants are tender and the frost heavy. Losses from frost have not in general been heavy at Forest Service nurseries. At the Savenac Nursery 1–0 western yellow pine, Douglas fir, and Engelmann spruce; at the Monument, Douglas fir and Engelmann spruce; at the Pocatello, 1–0 western yellow pine not under shade frames; at the Wasatch, 2–0 Douglas fir; and at the Boulder, 1–0 Douglas fir have been injured to some extent; while at the Wind River spring-sown seedlings of noble fir were badly injured by a late frost. At the Beaver Creek Nursery mulching with ripe timothy hay effectually prevented frost damage, but resulted in the production of a heavy crop of hay, which vastly increased the amount of weeding necessary in the nursery.

### INSECTS.

The principal insect damage which has been noted in the nurseries of the National Forests thus far has been due to cutworms, white grubs, grasshoppers, aphids, and pine-tip moths. The following information regarding life histories and habits of these insects and the general methods of combating them has been furnished by the Bureau of Entomology, which investigates insects affecting forest and shade trees and hardy shrubs, including forest nurseries.

#### CUTWORMS.[1]

Cutworms are the larvæ or caterpillars of night-flying moths and sometimes are destructive to young seedlings, cutting them off at or near the surface of the soil. They feed at night, concealing themselves in the soil or under rubbish during the day. Scratching the soil about an injured plant to a depth of one or possibly two inches usually reveals the worms, and this method of hand destruction of the larvæ may be practiced in small areas where the infestation is scattering.

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[1] For further information on cutworms and their control, see U. S. Dept. Agr. Farmers' Bulletin 739.

Cutworms may be destroyed also by means of a poisoned bait prepared and applied as follows: Mix 50 pounds of bran with 4 pounds of lead arsenate and 2 gallons of low-grade molasses until the mass is made into a stiff dough. The chopped oranges or lemons mentioned in the bulletin referred to (see footnote) are not always essential, but the molasses is absolutely so. In semiarid regions it is advisable to add water to prevent rapid desiccation and to distribute the bait toward evening. About a tablespoonful of the bait should be placed every foot or two along the nursery row. In case of migration from an adjoining field, the nursery may be protected by running a narrow band of the poisoned bait entirely around the edge or along the side nearest the source of infestation. A ditch constructed around the Savenac Nursery proved somewhat effective in trapping some of these larvæ which were migrating from an adjacent clover field.

### WHITE GRUBS.[1]

White grubs, the larvæ or young of beetles commonly known as May beetles or "June bugs," are often a serious menace to nursery stock, especially conifers, injuring or killing the seedlings and transplants by cutting off the smaller and girdling the larger roots. Most of the May beetles have a three-year life cycle, and except the one or two months (usually May and June) during which the beetles appear above ground to mate and feed, this entire period is spent underground, and two years of the three are spent in the grub stage. In the extreme northern limits of the United States, that is, in northern Wisconsin and Minnesota, where the grubs are important enemies of conifer seedlings and transplants, this insect has a four-year cycle, due to the shorter seasons. The grubs occur at various depths in the soil, and their proximity to the surface is largely dependent on the temperature and moisture conditions. They are found deeper during the winter months and more often quite near the surface in early fall. Plowing or cultivating the soil at this time, therefore, is of value, especially if done the year following the most severe summer injury, which would be the season the insects are transforming from grubs to beetles, at which time disturbances are usually fatal to them. The value of plowing or cultivating a field is greatly enhanced if poultry have the run of the field and are encouraged to forage during these periods. Each locality usually has one brood predominating, and the history of the brood should be learned, thus permitting the practices of persistent hand collecting of the grubs and beetles, spraying trees whose foliage is favorite food of the beetles with an arsenical during the flight of the beetles, and careful tilling of the land to prevent grass and weeds from making a growth during such flight, all of which are helpful expedients.

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[1] For further information on these insects, see U. S. Dept. Agr. Farmers' Bulletin 543.

### GRASSHOPPERS.[1]

Grasshoppers are often a serious menace in nurseries, and have been so at the old Garden City and the Page Creek Nurseries. The best poison remedies recommended against these insects are the poisoned-bran bait, described above, and the modified Criddle mixture. The latter is prepared as follows: Fresh horse droppings, one-half barrel; lead arsenate, 2 pounds; finely chopped oranges or lemons, 6 to 8 fruits, all thoroughly mixed. For protection against these insects the bait is best distributed broadcast over the nursery, and especially around the outer borders or open side, as circumstances may dictate. Fine screens around the seed beds and a brood of chickens at Trapper Creek have proved more effective than anything else tried.

### APHIDS.

Under certain climatic conditions aphids are apt to appear in greater or lesser numbers and do a corresponding amount of damage. These insects feed by sucking the sap of the plants, thus checking their growth and lowering their vitality. A woolly aphid has seriously damaged Jeffrey, western yellow, and Austrian pines at the Converse Flats Nursery, and was worse on the first-named species. Kerosene emulsion is one of the standard remedies and is especially effective if applied early in the spring, before the insects have multiplied excessively and the woolly species have covered themselves.

Kerosene emulsion is prepared as follows: Take 2 gallons of kerosene, one-half pound of laundry or fish-oil soap, and 1 gallon of water; dissolve the soap in hot water, remove the solution from the fire, promptly add the kerosene, and agitate the mixture vigorously for about 5 minutes until it becomes creamy—an emulsion. A most effective way of agitating the mixture is to pump it back into the original container for several minutes. To avoid boiling, a naphtha soap may be used, but the quantity of soap must be doubled and the water must be soft (rain water). This is the stock solution and it must be diluted with water before using, thus: To each 2 gallons of water add 1 gallon of the emulsion in the fall, and one-third of a gallon of emulsion in the spring. The size of the spraying apparatus will have to be determined by the size of the nursery. In most of them a knapsack sprayer will probably be most satisfactory. Using potash soaps and warm solutions, well strained, will prevent clogging of nozzles.

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[1] For further information on the habits of these insects and methods of control, see U. S. Dept. Agr. Farmers' Bulletin 747.

The other standard aphid remedy is 40 per cent nicotine sulphate, 1 part in 1,000 to 2,000 parts of water, with fish-oil or laundry soap added at the rate of 1 pound for each 50 gallons of the spray mixture.

### PINE-TIP MOTH.

A pine-tip moth has been injuring the western yellow pine at the Bessey Nursery, Nebraska, since 1909. The small larvæ effectually kill the succulent growing tips of these trees by boring into them. On account of the extensive distribution of the insect in the plantations adjoining the nursery, no effective practical remedy has as yet been worked out.

### BIRDS.

Mourning doves, juncos, the Canada jay, the blue jay, the red-polled linnet, and the black-headed grosbeak do some damage at the Forest Service nurseries by scratching up the seed or nipping off the tops of newly sprouted seedlings to which the seed coat is still attached. They are held in check either by poisoning with grain prepared in the same way as for mice or by shooting.

### RODENTS.

Rodents damage plants in a number of ways: By destroying seed in the seed beds, by digging in the nursery, by covering up plants, by girdling the stems, and by eating the tops, particularly during the winter. The white-footed mice, chipmunks, ground squirrels, gophers, and moles are the chief offenders. Against the first three and to some extent against birds several cats have been found to afford very good protection. Poisoning is also practiced. To be effective against mice and chipmunks the poison should be thoroughly distributed over the area immediately surrounding the nursery, under old logs, brush piles, outbuildings, rock piles, or any other likely retreat for these animals. Poisoning is most effective during spring or early summer before the natural food of these animals (seed and berries) ripens. Where mice work under a mulch and girdle nursery stock during the winter, the scattering of waterproof poisoned wheat throughout and under the mulch has been found effective in destroying them at the Monument Nursery. This bait is prepared as follows, in accordance with Circular 78 of the Biological Survey:

| | |
|---|---|
| Wheat | 1 bushel. |
| Tallow | 1 quart. |
| Saccharine[1] | 2 teaspoonfuls. |
| Strychnia (pulverized) | 2 ounces. |

The wheat should be slightly warmed, the saccharine and strychnia added, and the whole stirred thoroughly, and then the melted tallow applied.

Mice and chipmunks are also destroyed by sinking large cans to the level of the ground, partly filling them with water, and distributing seed on its surface. In attempting to secure the seed the rodents fall into the water and are drowned. About 700 were destroyed in this manner at the Pocatello Nursery in one season. Small baited spring traps placed near or upon the seed beds are quite effective in destroying mice.

At the old Garden City Nursery poisoned corn proved effective against kangaroo rats. At the Fort Bayard and the Pilgrim Creek Nurseries gophers are successfully combated by the use of gopher traps. At the Pilgrim Creek Nursery moles are effectively controlled by trapping. Carbide fumes were tried for driving out moles at the Page Creek Nursery, but were not effective. At the Converse Flats Nursery potato parings at the rate of one-half bushel to 1 ounce of strychnia (alkaloid) and 1 teaspoonful of saccharine are used to destroy digger squirrels. The parings are distributed in the burrows of these animals. At this nursery poisoned cracklings are found effective against chipmunks. This is prepared in accordance with the formula in Circular 82 of the Biological Survey, as follows:

| | |
|---|---|
| Coarse crackling meal | ¾ quart. |
| Strychnine (alkaloid) | 30 grams (1/15 ounce). |

Chop lard cracklings (fried down suet) to coarse meal (containing chunks one-fourth to one-half inch square). Slowly sprinkle with the powdered strychnine and mix constantly to distribute it evenly. Add one-fourth quart of fine crackling meal and mix well to cover the strychnine and disguise its bitter taste.

For some of the latest methods developed for combating rodents the Forest Service is indebted to Mr. S. E. Piper, of the Biological Survey. These are as follows:

Mix 1 heaping tablespoonful of gloss starch in one-half teacup of cold water and stir with 1 pint of boiling water to make a thin, clear mucilage. Remove from the stove. Mix together 1 ounce of powdered strychnine (alkaloid)[1] and 1 ounce of powdered bicarbonate of soda and stir with the starch to a smooth, creamy mass. Stir in 1 tablespoonful of glycerine and finally one-eighth ounce of saccharine. Apply to 20 quarts of good, clean oats or wheat and mix thoroughly to coat each kernel.

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[1] Saccharine is not essential.

This poison is effective in destroying chipmunks, kangaroo rats, pocket mice, the smaller species of ground squirrels, and at times kills white-footed mice.

Oats are generally the most successful bait. On account of the skill of chipmunks in "hulling," wheat is more effective for these animals. Barley, in the proportion of 16 quarts to each ounce of strychnine, has given best results in destroying the larger "digger" ground squirrels and is most effective during the dry summer season.

There is another process of applying the poison which is an improvement over that just described, in that it delays the taste of strychnine, the intense bitterness of which is the greatest factor detracting from success in poisoning certain rodents. This poison has been used with great effect against rodents which have hitherto exhibited marked aversion to strychnine baits. The fact that the poison coating readily separates from the bait is also of importance to the success of this preparation, especially for such rodents as habitually "hull" grain. In the process of hulling sufficient strychnine to kill flakes off in the animals' mouths. Grain poisoned in this way must be handled carefully to avoid loosening or grinding off the poison coating. It should be freshly prepared in small quantities, for use each day, as follows:

Mix together one-fourth ounce of powdered strychnine alkaloid, one-fourth ounce of powdered bicarbonate of soda, a scant one-half treasoonful of saccharine, two heaping tablespoonfuls of dry powdered starch; stir with enough cold water to make a thin paste of the consistency of cream. Apply gradually to the material to be used as bait, mixing vigorously to distribute the poison as evenly as may be and to prevent the formation of lumps.

Oats, wheat, cracked corn, and dry coarse meals of all kinds may be so poisoned. For ground squirrels, chipmunks, and medium-sized rodents generally, one-fourth ounce of strychnine is sufficient for 4 quarts of bait; but for white-footed mice the amount of bait may be doubled. Among baits especially attractive to the latter animals may be mentioned pine seeds (both whole and crushed seeds worth trial), roasted peanuts crushed to a coarse meal, crushed wheat, and mixtures of crushed or chopped grains.

Poisoned baits of sweet potato almost invariably kill pocket gophers if placed in the underground runs without too much disturbance of the latter. Baits of carrot or parsnip may be substituted, or corn, poisoned as in the first formula described, but none of these are so completely successful as sweet potatoes.

The baits of vegetables should be cut about 1 inch long and one-half inch square and washed and drained. From a pepperbox slowly sift one-eighth ounce of powdered strychnine (alkaloid) and one-tenth of this quantity of saccharine (ground together in a mortar) over about 4 quarts of the dampened baits, stirring to distribute the poison evenly.

The runways, which are usually 4 to 8 inches beneath the surface, can be located by means of a probe made of any strong handle an inch in diameter and 36 inches long. One end should be bluntly pointed. Into the other should be fitted a piece of three-eighths inch iron rod, protruding about 12 inches and bluntly pointed. A foot rest aids in probing hard soils. By forcing down this iron rod near gopher workings or a foot or two back of fresh mounds the open tunnel can be felt as the point breaks into it. The blunt end of the instrument is now carefully used to enlarge the hole, a bait or two is dropped into the run, and the probe hole closed.

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[1] If strychnine sulphate is used, dissolve in the boiling water before adding the starch; also dissolve the bicarbonate of soda before adding to the poisoned starch. Care is necessary that the resulting mixture does not greatly exceed a pint.

Baits need to be placed at only two points in each separate system or group of 10 to 30 mounds, which is usually the home of a single gopher. In our experience baits placed in open underground runs have invariably killed the gophers. The method has found great favor wherever it has been introduced.

At the Converse Nursery, in California, wood rats, or "pack" rats (*Neotoma*), have been found responsible for a considerable part of the damage to transplants usually ascribed to rabbits.

Wood rats eat little or nothing of the trees they cut, but carry the green tips into their nests to store away. These animals are rarely killed by any of the baits which have been described, though they pack away such baits readily enough. Effective results have been obtained by dusting baits liberally with finely powdered strychnine, as the rats are killed in packing them. Dry oatmeal biscuits one-half inch square and one-fourth inch thick, cut from a stiff dough of oatmeal and water, after rolling it in sheets, have proved to be especially successful baits. Raisins and whole corn may also be used.

Though both cottontails and jack rabbits fall victims to poisoned oats during periods when their natural food is scarce, this poison can not always be relied upon to destroy them when it is most important to check their depredations. Green or ripening grain heads of barley or wheat are among the most attractive baits in summer. Soaked for 48 hours or more in a solution of 1 ounce of strychnine sulphate and one-eighth ounce of saccharine in 2 gallons of water, such baits have occasionally proved very successful. They should be used only in locations where live stock is not endangered.

## FERTILIZERS.[1]

The character of soil preferable for a nursery has been described, but such soils are not always to be found. Continuous raising of crops of trees, moreover, will eventually deplete even the best soils of the chemical constituents most essential for plant growth. It will also impair their physical qualities. Improvement of the soil by fertilization will accordingly be necessary. According to investigations by von Schroeder,[2] the average quantity of nitrogen, potassium, and phosphoric acid (the three most essential plant foods) needed in one year by 1 to 3 year old spruce is about equal to the amount absorbed from the soil by a crop of corn, potatoes, or meadow hay. The physical and chemical qualities of a soil may be improved through the addition of manure, leaf mold, compost, or marl, and chemical fertilizers. Some of the chemical fertilizers, however, rapidly pass into solution and have no appreciable effect upon the physical quality of the soil.

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[1] The information cited in regard to fertilizers is taken, but not wholly verbatim, from "Die Pflanzenzucht im Walde," by Dr. Herman von Furst, and represents the views of German nurserymen.

[2] "Tharandter Forstliches Jarbuch," 1893–94.

Two classes of fertilizers may be distinguished: "Complete" fertilizers, which contain all the important elements necessary for plant growth, and "incomplete" fertilizers, which furnish only one or more of these elements.

### COMPLETE FERTILIZERS.

Stall manure, consisting of the animal excrement and the litter on which it is found, is a very effective fertilizer, not only because it contains the most essential plant foods—nitrogen, potassium, and phosphoric acid—but because it improves the physical qualities of the soil and by numerous microorganisms increases its activity and fermentation. Sheep and horse manure are richest and decompose rapidly. Cattle manure decomposes less rapidly. The former is best for application to compact, the latter to loose soil. As manure is not usually to be had in sufficient quantities at a nursery and is often difficult and expensive to obtain, it is frequently used in compost.

Where humus can be obtained it has been found to be excellent, both as a fertilizer and for its effect in improving the physical quality of the soil.

The value of compost as a fertilizer is decided by the material entering into it and the treatment given compost heaps. Organic substances of every kind may be used for this—weeds, raw humus, turf, and even street sweepings. To this material is added quicklime for more rapid decomposition and horse manure in layers. Ashes may also be used to strengthen it. Weeds hoed from the nursery may be used alone for compost. In such cases it is necessary to mix them in thin layers with quicklime, allow the heaps to remain untouched for some time, and then stir repeatedly. When thoroughly decomposed it is ready for use.

One of the German head foresters gives the following formula for making good compost: The first layer, about ½ inch thick of organic substances, grass, heather, weeds, sawdust, etc., is sprinkled with a thin layer of unslaked lime, then another layer of grass and weeds is added, then a layer of lime, etc. In this manner it is heaped up like charcoal but shaped broader and lower so as to catch the rain, and then covered on all sides with carefully crushed earth. The slaking of the lime begins after a few days and in from 2 to 4 days later is completed. During this time the heaps should be examined twice a day and all crevices in the earth covering closed in order to keep the heat, steam, and ammonia from escaping. After from 4 to 6 weeks the material is ready for use.

## INCOMPLETE FERTILIZERS.

### WOOD ASHES.

With the exception of nitrogen, which is lost during the process of burning, wood ashes contain all the nourishing substances, potash, lime, phosphoric acid, magnesia, and sulphuric acid, in a form capable of absorption. Wood ashes may accordingly be added to the list of fertilizers for general use. The quantity of these elements, particularly phosphoric acid and potash, contained in the ashes varies with the species, the ash of hardwoods being much richer in such material than that of conifers. In sandy soil care must be taken in using wood ashes, because such soil is not capable of much absorption. The use of such a strong fertilizer has an unfavorable effect, because it furnishes the roots with too much carbonate of potash, which acts as an alkali; on the other hand, its use on clayey humic soil is very favorable. Pure wood ashes, however, are seldom used but are generally mixed with compost; their use deserves all the more consideration, as they can usually be obtained at little expense by burning the brush around the nursery or by utilizing the wood ashes from the stoves of the nursery buildings.

### NITROGEN FERTILIZERS.

Nitrate of soda $NaNO_3$ (Chili saltpeter) contains 15 or 16 per cent of nitrogen, is easily dissolved by water, and quickly distributed. It has a quick and decisive effect, but the portion not absorbed at once by the plants quickly sinks to the subsoil and may be lost. Its best use is for intermediate fertilizing—that is, the fertilization of beds in which after the growing season has started the plants appear unhealthy and the cause is apparently due to lack of nitrogen.

A somewhat better commercial nitrogen fertilizer for forest tree nurseries is ammonium sulphate $(NH_4)_2SO_4$, obtained from the refuse in gas manufactories where the ammonia produced is fixed by sulphuric acid; the white salts contain about 21 per cent of nitrogen, which is only effective after being changed into nitrates. A simultaneous fertilization with lime or carbonate of lime should be avoided, as in such a case by decomposition of the salts the ammonia becomes ineffective and evaporates.

Blood powder or blood guano, made from the blood of slaughtered animals mixed with powdered lime, contains from 10 to 12 per cent of nitrogen and from 1 to 2 per cent of phosphoric acid. Horn powder made from the refuse of horns, hoofs, and hair, ground and dampened, contains from 10 to 12 per cent of nitrogen and from 5 to 6 per cent of phosphoric acid. Both of these substances act rapidly.

### POTASH FERTILIZERS.

For the introduction of potash two salts, kainite and carnallite are good. These salts contain sulphuric acid and magnesia in addition to potash. Their use, especially that of the kainite, must be watched carefully, as the chloride easily corrodes the plants, so that too great a quantity should be avoided, especially directly before sowing or transplanting. Disregard of such precautions may lead to the total destruction of the plants. The most practical method is to mix the kainite in the compost heaps with the addition of lime, thus neutralizing the effects of any chlorine that may be liberated.

### PHOSPHORIC ACID FERTILIZERS.

Bone meal and Thomas meal, also known as Thomas slag or basic slag, may be used to supply the soil with phosphoric acid. Crude dry bone meal contains from 20 to 22 per cent phosphoric acid and from 4 to 5 per cent nitrogen. Thomas meal, a by-product in the manufacture of steel, which is more generally used in European nurseries, contains from 11 to 23 per cent of phosphoric acid and from 38 to 39 per cent of lime, besides iron, manganese, silicic acid, and magnesia. Possible damage may arise from the use of Thomas meal if it is applied just previous to planting the beds.

### LIME FERTILIZERS.

Lime is not only an important plant substance found in all plant ashes, but it has an important influence on the soil; it hastens the disintegration as well as the decomposition of the organic substances, neutralizes the free acids which may be injurious to the plants, such as humic and phosphoric, and makes the soil loose and friable. Some of the other fertilizers mentioned, bone dust and Thomas meal, contain lime, but with soil very deficient in lime a heavier addition may be necessary. For this purpose burnt lime, carbonate of lime, or marl may be used.

The burnt or unslaked lime is the most effective form. It contains from 90 to 95 per cent of lime and is generally used as part of a compost. It may also be placed directly on the ground in small heaps and then slaked by pouring over it one-third its weight in water and covering with a layer of earth 3 or 4 inches thick. In 24 hours it will change to a fine powder and should then be spread around and worked into the soil.

The carbonate of lime is a natural product and is simply applied in a pulverized state. When mixed with sand and clay it forms marl, a substance which is often found naturally in large beds and which can be applied directly as a fertilizer. It is an especially good material to add to light, sandy soil, on account of the clay contained.

### GREEN FERTILIZERS.

The use of green fertilizer is the easiest and perhaps the cheapest method of supplying soils with nitrogen, and as it adds humus it improves their physical quality as well. The method consists in the raising of rapid-growing herbaceous plants and plowing them under before the stems become woody. The leguminous plants are preferred for this purpose. They have the ability, with the aid of the microorganisms in the soil to assimilate the free nitrogen of the air and store it in the root tubercles. A number of plants may be used, among which are the lupines, yellow lupine in particular, different kinds of vetch, field peas, cowpeas, beans, soy beans, dwarf beans, frijoles, and serradilla. Engler found that on all soil rich in lime field peas and cowpeas furnish the richest fertilization; on rather moist soil with little lime the yellow lupine is the most suitable; vetch is suitable only for heavy and compact soil and furnishes a cheap but not so rich a fertilizer; in high localities with rigorous climate and later sowing the field pea is recommended. Cowpeas are the most expensive, but they produce the greatest volume and, on account of their strong root development, are especially to be recommended for rough, hard soil or for soil which has long lain fallow.

Vigorous growth of leguminous plants and the assimilation by them of free nitrogen is dependent upon the presence in the soil of certain fungi which live in a symbiotic relation with the plants. When such fungi are not present—their absence is indicated by the poor growth of the plants—they must be introduced. This is accomplished by the so-called inoculation of the soil. Surface soil from other fields where legumes have grown in a flourishing manner is collected and sown over the new area at the rate of about 100 pounds per acre. The same result can also be secured by the use of inoculating fluids, with which the seed are moistened.

### CHOICE OF FERTILIZERS.

If only the chemical qualities of the soil need improvement chemical fertilizers may be introduced, but if the physical qualities need improvement the addition of humus will be necessary. The chemical fertilizers necessary can best be determined by experiment. Analyses of soil are inconvenient and expensive and give only temporary results, because the contents of the soil change with each year's production of plants. It is preferable not to use fertilizers which contain only one of the desirable elements. However, if this is necessary, it should be remembered that the growing of cover crops is the most inexpensive way of introducing nitrogen; that phosphoric acid can be introduced by the use of Thomas meal and bone meal, both of which also add lime to the soil; and that potash is most cheaply introduced by the use of kainites.

Commercial fertilizers (with the exception of those containing lime) do not improve the texture of the soil to any extent, and lime does not improve loose soils; commercial fertilizer is rather rapid in its action, making it preferable where quick effects are wanted, but is likely to be quickly lost through leaching out; it is expensive and sometimes difficult to obtain; and some of it contains only one or two of the elements essential to plant growth. Manure is also often difficult and expensive to obtain in sufficient quantities; if mixed with much litter not well decomposed it is likely to cause drying out of the beds; and it does not give such immediate results. On the other hand, it does not leach out rapidly, it improves the texture of both heavy and light soils, and it furnishes several of the elements which are essential to plant growth.

In choosing fertilizers the absorption capacity of the soil must also be considered. This is much greater in fine and clayey than in sandy soil; in the latter there is always danger of any soluble substance, such as saltpeter, being washed out. In such cases the nitrogen is best furnished by green fertilizing and stall manure, and lime by carbonate of lime instead of unslaked lime.

## TIME AND METHOD OF INTRODUCING FERTILIZERS.

Inferior soil, even before the first crop is grown, should be fertilized. Fertilizer should be applied at a time when it will prove most beneficial to the plants. Stable manure which has not been well rotted should be applied the fall or winter previous to the spring planting. Such manure can be used just before sowing or planting if it is turned far enough under the soil so that it will not come in contact with the roots. Compost, bone meal, and slaked lime or carbonate of lime may be applied just previous to the sowing or planting of the beds.. Thomas meal, kainite, and carnallite should be applied the previous autumn, or the last two in the spring just before sowing or transplanting, if used only in small quantities. Chili saltpeter should be scattered on the ground and worked in between the rows after the seed has sprouted, because it dissolves easily and is carried quickly into the soil by rain. The other fertilizers mentioned should be well mixed with the soil which makes up the root zone. It is better not to fertilize too deeply in order to encourage lateral development of the roots rather than development in depth. The application of too great a quantity of fertilizer is not to be recommended. Aside from the expense it is likely to be injurious. Observations indicate that highly fertilized plants are more susceptible to heat; they do not lignify so readily in the fall, and that they are subject to frost danger.

### PRACTICE AT FOREST SERVICE NURSERIES.

At the majority of Forest Service nurseries fertilizing has not been accorded much attention because they have been quite recently established, and there has not been opportunity to study this question. At the Bessey Nursery horse manure is invariably mixed with sand and is not used until it has composted thus for a year, during which time it is turned two or three times and watered as often as necessary to prevent heating. It is applied at the rate of from 50 to 120 tons per acre and a crop of cowpeas or soy beans is produced on the area before it is again devoted to nursery purposes. It has been found here that soy beans produce more and larger root nodules than cowpeas. The application of fresh horse manure to the seedbeds just before sowing has proved unsatisfactory, because the undecomposed material made the soil so loose that it dried out very rapidly, resulting in loss of seedlings from drought.

At the Fort Bayard Nursery horse manure is applied at the rate of from 25 to 30 tons per acre, and then frijoles (Mexican beans) are grown for one season on the same area. These have not been plowed under. Crops of frijoles and nursery stock are rotated yearly.

At the Monument Nursery, after the trees are removed in the spring, the area is given a liberal application of well-rotted barnyard manure, which is plowed under to a depth of about 10 inches, and it is then sowed to field peas at the rate of about 75 pounds per acre. When the peas begin to blossom they are plowed under and a second crop sown to be plowed under just before the vines freeze. On the seed-bed area this operation is repeated the following year, but transplant areas are ready for use after one year's treatment.

At the Pilgrim Creek Nursery sheep manure is applied just before spading the beds at the rate of 4½ cubic feet to 144 square feet of seed-bed surface and 45 cubic feet to 700 square feet of transplant-bed surface. The amount for transplant beds is to be increased, as it is not considered sufficient.

At the Garden City Nursery manure and cowpeas were used in rotation with the nursery crops. Sand was also added to the heavy soil and improved it considerably.

Because of the great increase in damping-off which has resulted in some cases from the use of organic fertilizers, especially dried blood, it is well to warn against the use of any rich organic fertilizers shortly before seed sowing. Ammonium hydroxide when applied at the old Garden City Nursery was followed 3 or 4 weeks later by the almost complete destruction of the seedlings, apparently by damping-off fungi, although it is not absolutely certain that fungi were responsible.

## COSTS OF OPERATIONS.

The cost of nursery operations, which are reflected in the costs of stock, are governed by so many conditions that they vary considerably at different nurseries and from year to year. The different elements which effect the cost have been pointed out in the foregoing pages. With the bringing of all nurseries up to a good economic capacity, with a gradual decrease of overhead charges, which in some instances are at present rather high, and with still more improved methods of nursery practice and familiarity with the different species, it is expected that average costs can be considerably reduced in the future. The following represent some of the actual costs of past nursery operations:

| Operation. | Cost per thousand. |
|---|---|
| Growing 1-0 stock | $0.33 to $1.50 |
| Care of 2-0 stock | .06 to .50 |
| Transplanting stock | .77 to 2.04 |
| Care of transplants first year | .18 to 1.03 |
| Digging, packing, and shipping of stock | .74 to 2.43 |

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UNITED STATES DEPARTMENT OF AGRICULTURE

# BULLETIN No. 480

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. ▲ June 30, 1917

# SOLID-STREAM SPRAYING AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH IN NEW ENGLAND.

By L. H. WORTHLEY, *Agent in Charge of Scouting and Extermination Work, Gipsy and Brown-Tail Moth Investigations.*

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## INTRODUCTION.

In nearly all parts of the United States damage is produced each year by leaf-eating insects, and the application of arsenicals, in the form of poison sprays, has been demonstrated to be the most efficient method of suppression or control. In the work of suppressing and preventing the spread of the gipsy moth and the brown-tail moth, spraying with arsenate of lead on an extensive scale has proved a very important factor. The magnitude of the insect problem which the ravages of the gipsy moth has developed in the New England States made it necessary to devise extensive improvements in insecticides and spraying machinery.

## HISTORY.

When the work against the gipsy moth was first undertaken by the Commonwealth of Massachusetts, the problem was one of extermination rather than repression, and spraying with arsenical poisons at that time was not regarded as an important factor. The State Board of Agriculture of Massachusetts later conducted experiments with insecticides which resulted in 1894 in the development of arsenate of lead as the most economical and effective poison for control work against leaf-eating insects. After these demonstrations, spraying became more general, owing to resulting effectiveness as well as to a considerable reduction in expense, and this naturally led to the modification and improvement of machinery and apparatus for applying mist sprays.

In 1895 the late J. A. Pettigrew, while superintendent of Prospect Park, Brooklyn, N. Y., began solid-stream spraying, and in the Yearbook of the United States Department of Agriculture for 1896 there appears an article by Dr. L. O. Howard on the subject. The sprayer assembled by Mr. Pettigrew had steam as its motive power, the pump and engine being connected to a watering cart. (Pl. II.)

Owing to the discontinuance of appropriations by the Legislature of Massachusetts, the gipsy-moth work was stopped in 1900, and no State work was carried on in combating this pest until May, 1905, when a further appropriation was made.

In 1905 the late Gen. S. C. Lawrence, of Medford, who was intensely interested in the work of combating the gipsy moth on his large estate and others surrounding it, saw the necessity of larger machines for spraying and purchased a high-power machine which was operated by an air-cooled gasoline engine and had a triplex cast-iron pump. This machine did very good work, but its use indicated that further improvements were desirable.

Through the efforts of the writer, while in the employ of the State of Massachusetts, some important mechanical devices in solid-stream spraying were constructed, and during the last few years, while carrying on the scouting and extermination work for the Bureau of Entomology, United States Department of Agriculture, further improvements have been made. Many of these improvements are now being extensively used in New England, but in order that others contemplating the use of such apparatus may know the most economical and practical methods the following suggestions, illustrations, and tables are submitted.

After a careful inspection of the territory surrounding the known infested area in Massachusetts, it was found that it had increased from 359 square miles in 1900 to 2,500 square miles in 1905. It was apparent that a considerable amount of spraying must be done, but the apparatus available for so large an operation was insufficient and indequate, there being hardly any spraying machinery on the market except that principally used for orchard spraying. After the first season's work efforts were made to improve spraying machinery, so that the work could be brought to a higher degree of efficiency. Our efforts led to the construction of a high-power solid-stream machine, which was an improvement over those used in the previous season. These machines were assembled from stock parts purchased in the open market and consisted of stationary engine, with battery ignition and single cylinder or duplex pump.

While the results accomplished were an improvement, they were not satisfactory as the pump did not furnish a steady pressure and the engine caused too much vibration. In 1907 a two-cylinder marine engine and triplex cast-iron pump were used. This machine was an improvement over the first, but the pump would not stand high pressure and its use resulted in a large amount of valve trouble. Later a four-cylinder marine engine was used with high-tension magneto and a triplex pump made of phosphor-bronze having metal valves. This proved satisfactory, and practically the same outfit is in use to-day.

## DESCRIPTION OF APPARATUS.

The high-power solid-stream sprayers being used by the Bureau of Entomology are assembled as follows (Pl. III):

Caravan running-gear, U-shaped tank, phosphor-bronze pump, 14-horsepower marine engine. Running gear built of best oak stock with high-grade iron. Wide tires on wheels, cut-under front wheels, with springs all around, fitted for a two-horse hitch. Tank made from select pine stock, capacity of at least 400 gallons, with a solid roof capable of carrying supplies on the top. An arch made of heavy steel straps is bolted on the inside to protect the agitator. This arrangement provides space in the tank for storing the hose while the sprayer is being moved from place to place and eliminates the need of a supply wagon, reducing the cost of operation about $5 a day. The roof extends over the engine, and side curtains are used to protect it from weather. Pump, triplex type, with cylinders, valves, valve chambers, and plungers made of a high-grade phosphor-bronze with a tensile strength of 35,000 pounds per square inch. This makes a much lighter and more compact pump than would be safe if cast iron was used, as the latter rarely has a tensile strength of more than 15,000 pounds per square inch. The cylinders and displacement chambers are cylindrical in design, so as to offer no flat surfaces to pressures; thus greater strength can be secured with the same amount of metal. The valves and waterways are extra large to permit high speed while filling. The valve chambers are so designed that any one valve may be removed without disturbing another. The uprights are made of high grade iron with babbitted bearings. The crank is a drop-forging which usually has an elastic limit of over 74,000 pounds per square inch and is not subject to crystallization. Cast-iron cranks should be avoided, as they usually have an elastic limit not exceeding 40,000 pounds. The pump is attached to the engine by a durable clutch, with gear and pinion. Connected with the pump are two automatic safety release valves, one set at 300 pounds and the other at 350 pounds. By having two release valves a variation of pressure can be obtained from 275 pounds to 375 pounds without making any change in the release valve and not running the engine at an excessive rate of speed. These valves are properly set and should not be adjusted in the field.

## THE ENGINE.

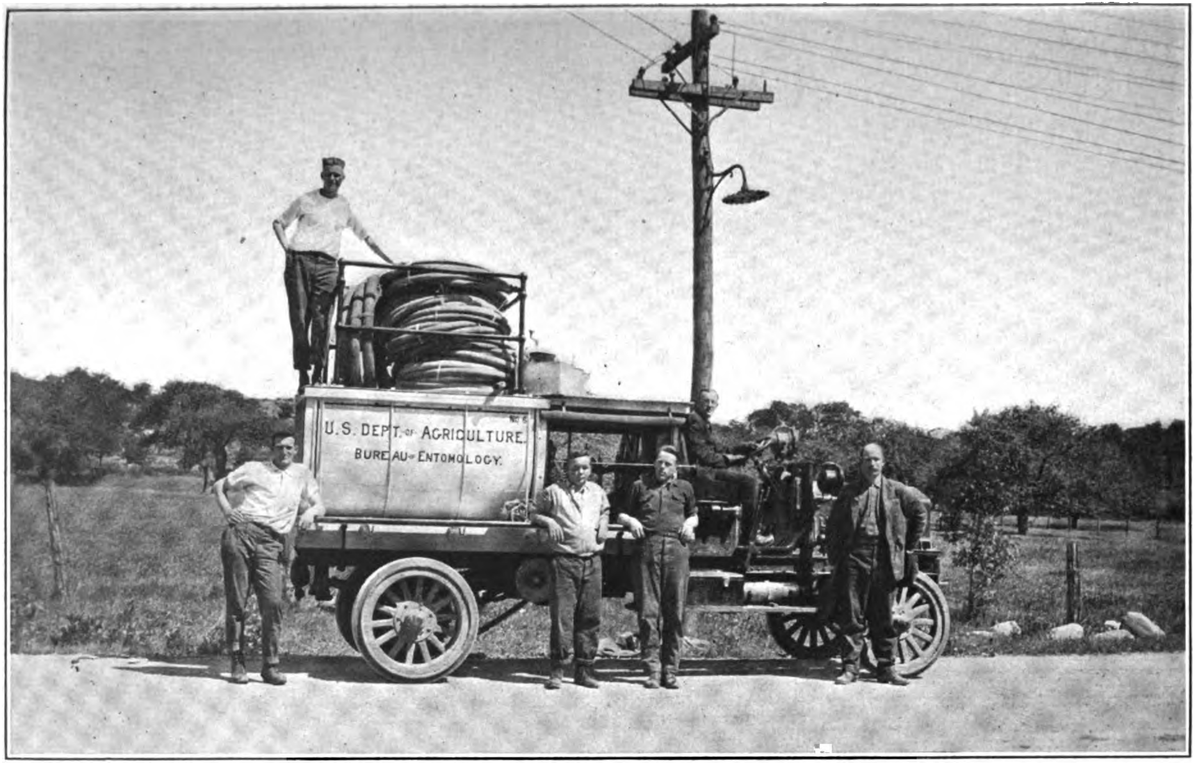
The engine is a 4-cycle, water-cooled type, having four cylinders, with a maximum of 14 horsepower, and is equipped with a high-tension magneto, and so oiled as to require little attention from the engineer. The cooling system consists of a coil of pipe submerged in the spray tank and fed by a supply tank located near the engine. The gasoline tank has a capacity of 10 gallons. The agitator consists of three long paddle blades extending the entire length of the tank and has proven more satisfactory than single propeller blades.

The safety or release valve is so arranged on the delivery line that the solution is automatically released into the spray tank whenever the nozzles are shut off. The piping, wherever subjected to high pressures, is extra heavy, with double-strength fittings, and is so arranged on the pressure side that the solution may be delivered into the hose for spraying or diverted into the tank when filling. The suction line is arranged so that the solution may be drawn directly from the tank or water from the suction hose when the tank is being filled.

While this arrangement is not essential in spraying work, it enables this apparatus to be used for other purposes, such as fighting fires, etc.

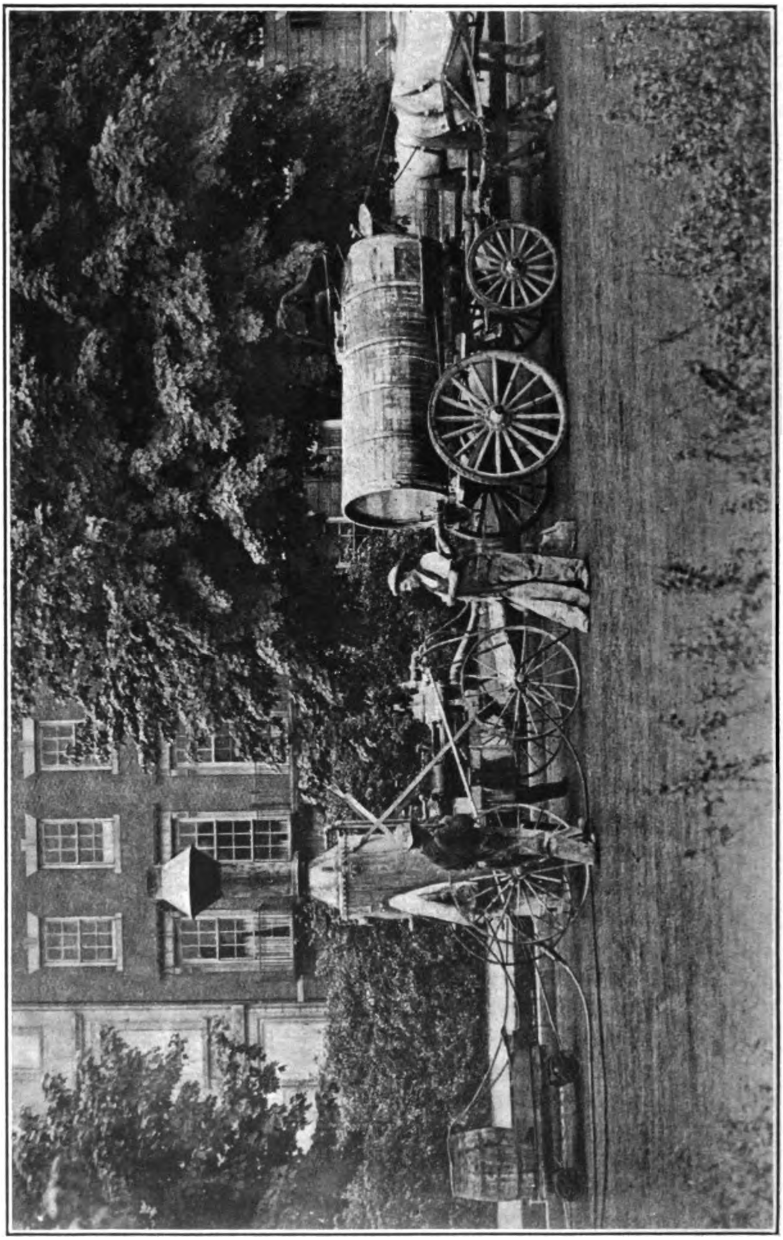
## THE HOSE.

Hose used in high-power solid-stream spraying should be constructed to stand a working pressure of 600 pounds, with couplings especially adapted for high-power work. Hose used in this work not only has to stand high pressures, but is also subject to severe strain in pulling and hauling that is necessary especially in woodland spraying. Unless a very high grade 10-ply hose is used, with heavy inner tube and outer walls, it is advisable to have 7 or 8 ply hose covered with a cotton jacket treated to prevent mildew and increase wearing quality. It is also advisable to use high-grade hose, whether covered or not, as the life of it will be so extended as to reduce the yearly cost to a considerable extent. Couplings should be constructed so as to make it impossible for them to blow off under pressure and to offer as little resistance as possible when the hose is being pulled. In woodland spraying parts protruding from cou-



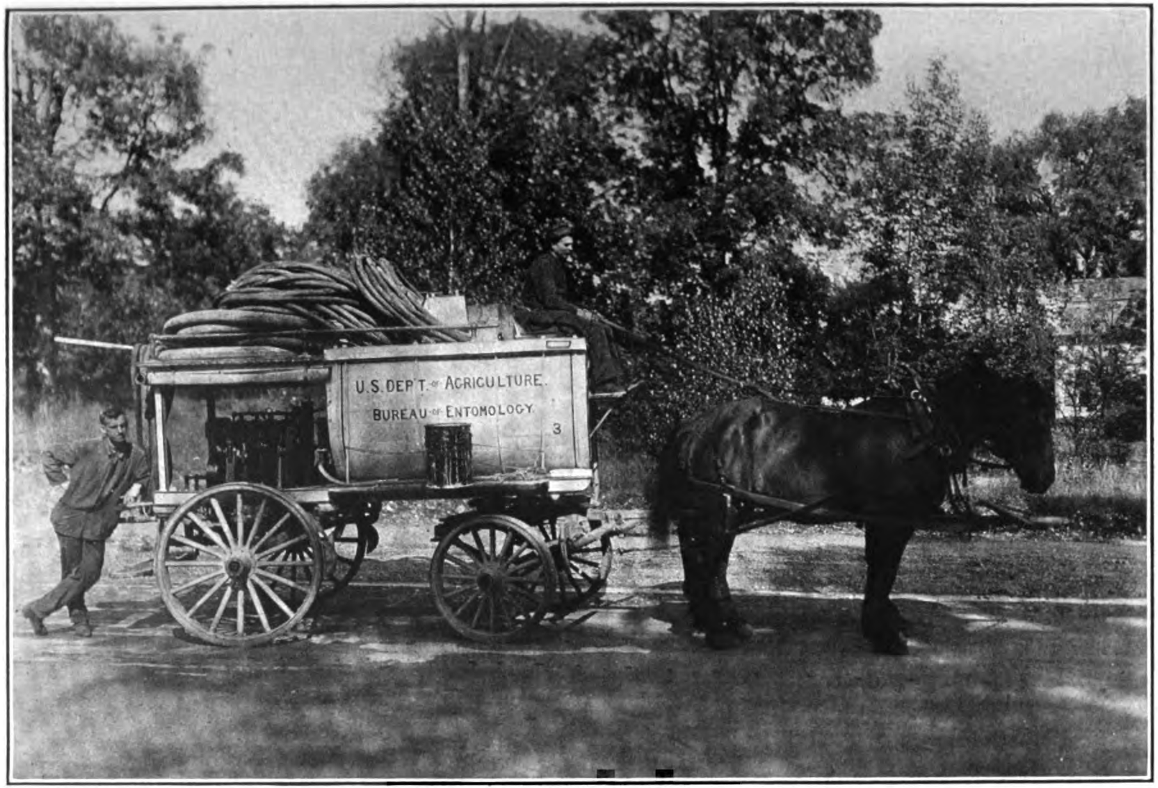
SPRAYING AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

Motor-truck sprayer of the Bureau of Entomology with crew and equipment. (Original.)



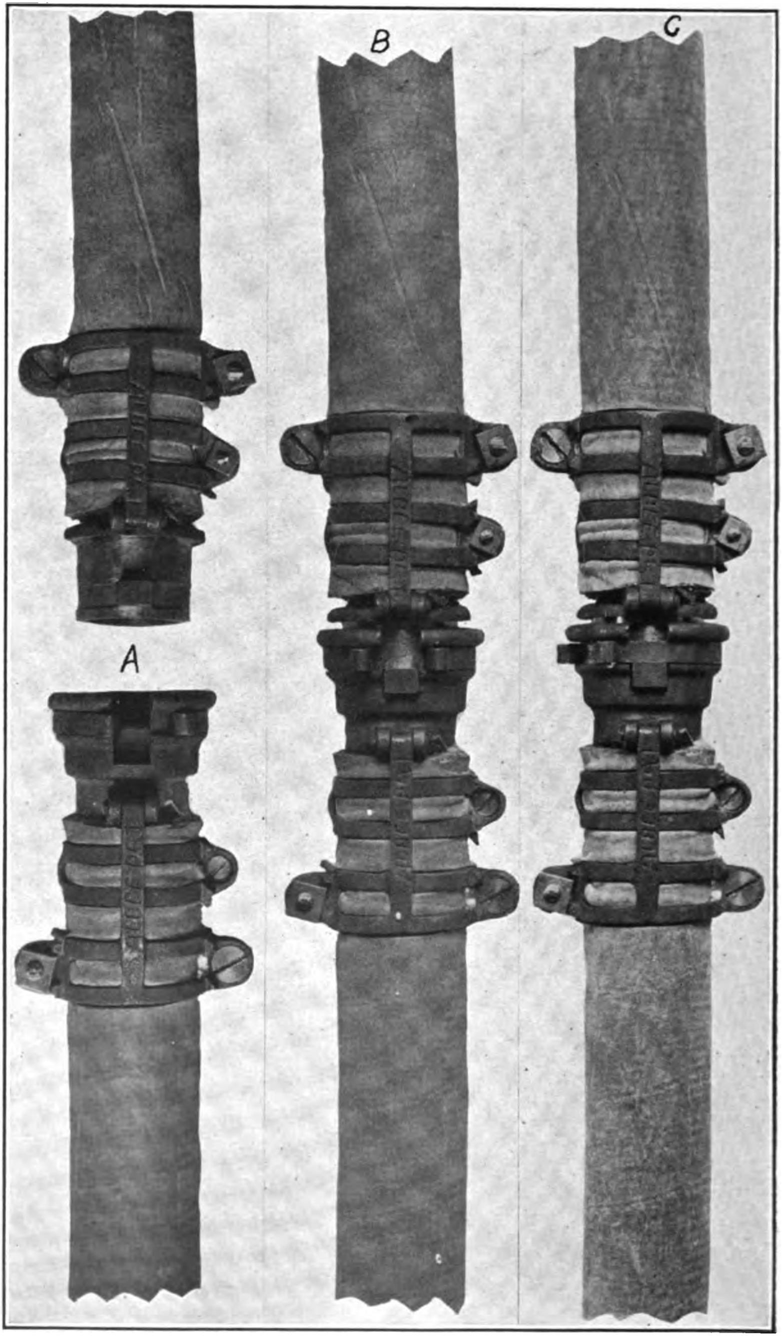
AN OLD TYPE SOLID-STREAM SPRAYER.

Sprayer built by Mr. J. A. Pettigrew and used in the Boston parks in 1907. (Original.)



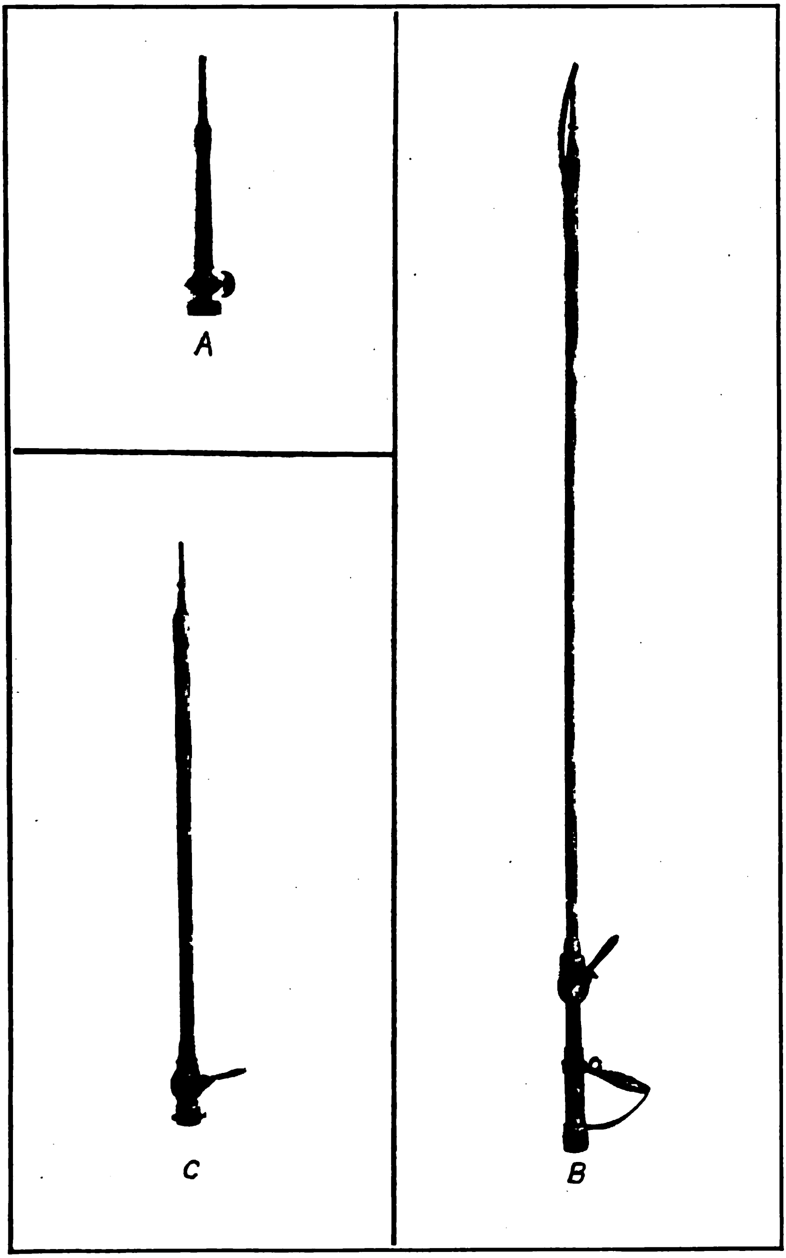
THE SPRAYING OUTFIT IN USE TO-DAY.

Present type of horse-drawn high-power solid-stream sprayer with equipment. (Original.)



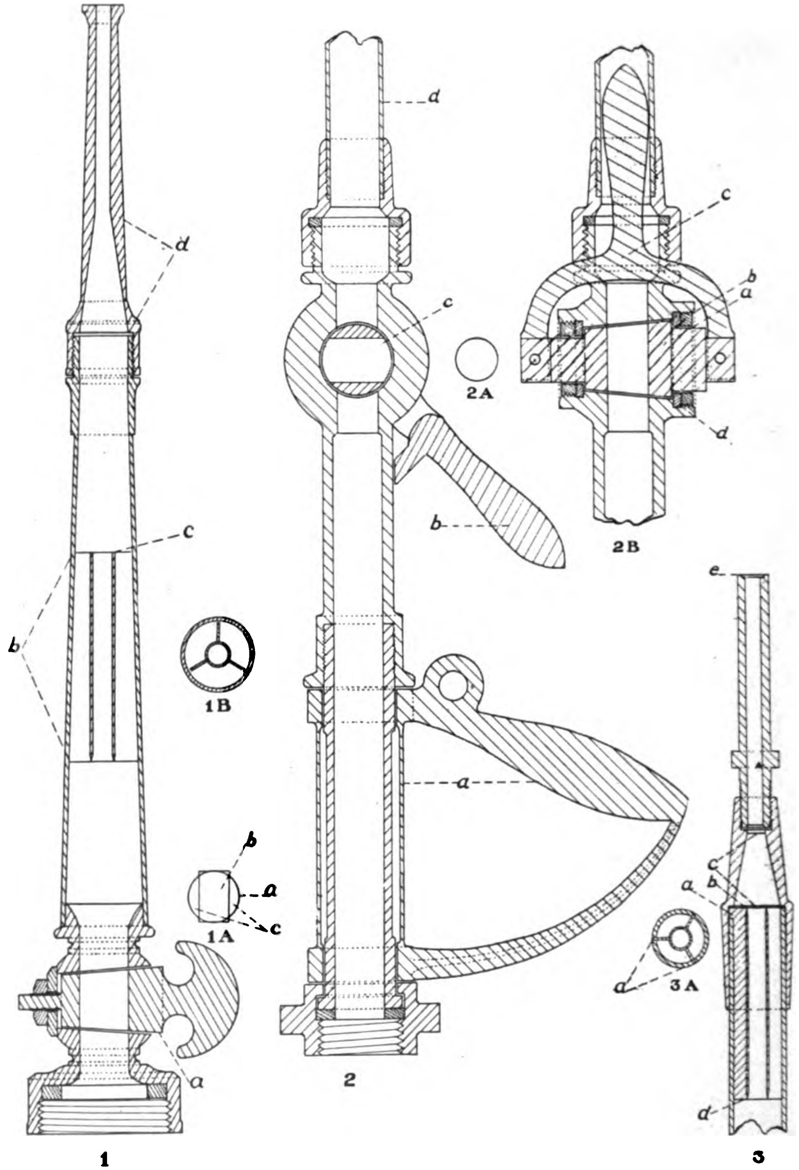
A NEW FEATURE IN HOSE COUPLINGS.

**High-power hose equipped with quick-hitch couplings. A, Uncoupled; B, coupled but not fastened; C, coupled and fastened. (Original.)**



COMPARISON OF OLD AND NEW TYPE NOZZLES.

Nozzles for solid-stream sprayer. A, Old type nozzle; B, latest type, known as the Worthley nozzle, with spreader; C, smaller size, same type as B. (Original.)



COMPARISON OF DETAILS OF THE OLD AND THE IMPROVED TYPES OF NOZZLES.

FIG. 1.—Old type nozzle. *a*, Shut-off open; *b*, Hopkins; *c*, square top of Hopkins; *d*, taper at base of tip. FIG. 1A.—Square waterway in shut-off; *a*, opening of pipe above and below shut-off; *b*, rectangular opening in shut-off; *c*, protruding shoulder in shut-off when open. FIG. 1B.—Cross section of tube and Hopkins, showing Hopkins loose in the chamber of the nozzle.

FIG. 2.—Base of Worthley nozzle. *a*, Swivel handle; *b*, shut-off handle; *c*, shut-off closed; *d*, base of tube of nozzle. FIG. 2A.—Clear waterway in shut-off when open. FIG. 2B.—Details of the shut-off; *a*, shut-off open; *b*, nut; *c*, shut-off handle; *d*, washer.

FIG. 3.—Tip of Worthley nozzle. *a*, Method of holding Hopkins in position in top of tube; *b*, top of Hopkins leveled to sharp edge; *c*, condensing head in end of tube; *d*, beveled base of Hopkins; *e*, protecting shoulder. FIG. 3A.—Cross section of tube and Hopkins. *a*, Hopkins firmly held in place at top of tube. (Original.)

plings are a great hindrance to the work, as they become entangled in twigs, rocks, and other obstructions. Recently there has been placed on the market a quick-hitch coupling that is easily connected without the use of wrenches and is being used by this Bureau in its spraying work. It promises a great saving in time when long lines of hose are being used. (Pl. IV.)

## NOZZLES.

From observations made by the writer on solid-stream spraying operations in 1907, 1908, and 1909 it was evident that the nozzles being used were not giving satisfaction and that some improvement should be made. The nozzle then in use had a long, tapering tube with the shut-off near the tip or at the base and was constructed so as to offer considerable resistance to pressure. (Pl. V, *a*.) The "hopkins" (a finlike arrangement used in open-bored nozzles to stop the circular movement) was placed near the hose end and the tips were tapered nearly to the end, which caused the stream to spread, by reflex action, immediately after leaving the tip. Water passing through lines of hose takes a spiral motion, owing to the spiral winding in the manufacture of the hose.

Experiments were conducted in 1909 and 1910 for the improvement of solid-stream nozzles, and resulted in the production of a nozzle that gave much more satisfaction, gaining at least 25 feet in the height of the stream, working at the same pressure, with the same size tip, and using the same amount of solution. Later it was observed that some means should be devised for breaking the force of the stream, so that small trees and the lower foliage of large trees could be properly sprayed. For this purpose a strip of brass, slightly curved, about 10 inches long and 1¼ inches wide, known as a spreader, was attached to a brass ferrule about a foot in length, so that it could be moved up and down the tube of the nozzle. When this brass strip is slid beyond the tip the force of the solution coming in contact with it is broken up into a fan-shaped stream, thus giving a good mist spray. (Pl. V, *b*, *c*.)

Solid-stream nozzles now being used have a full-way shut-off at the hose end which is packed on both sides to prevent leakage, and a reduction is made in the condensing head for a tapered way of approximately 1 inch in length. The "hopkins" is placed directly in the end of the tube, straightening the stream practically at the tip entrance. The tips are all bored from solid metal, making an absolutely smooth waterway. A swiveled handle is provided on the large nozzles to permit them to turn freely when the hose twists, without annoyance to the nozzleman. The introduction of this nozzle practically eliminated the climbing of forest trees in spraying. For full details of construction, see Plate VI.

## MOTOR-TRUCK SPRAYER.[1]

The first motor-truck sprayer used in New England was built in the winter of 1910 along lines suggested by the writer. This sprayer was used by the State of Massachusetts and gave such satisfactory results that several others have been built and are being used in that State. (Pl. I.)

In the fall of 1915 a machine of this type was built for the Bureau of Entomology and has been used to great advantage during the past summer.

Profiting by the experience secured when the other machines were constructed, the one built for the Bureau was improved and perfected in many respects, so as to render its operation more perfect and economical. A machine of this type is particularly useful where work has to be done in locations demanding the use of long lines of hose and where water must be hauled long distances. It can accomplish more work in a single season than four horse-drawn high-power sprayers and can be operated more economically on account of saving time on the road and reduction in the number of men needed.

One and one-eighth inch hose is used on this machine, as it does not offer as much resistance as the hose of smaller diameter, and makes it possible to maintain proper pressures at the nozzle when 2,500 feet of hose is required. Two automatic safety release valves are connected to the pump, one set at 300 pounds and one at 500 pounds. The maximum pressure needed on 2,500 feet of 1⅛-inch hose to obtain 225 pounds at the nozzle is 475 pounds, against approximately 600 pounds in the case of 1-inch hose.

When 1-inch hose is used the pressure must be increased 50 pounds for every 100 feet that the nozzle is operated above the level of the sprayer. With 1⅛-inch hose a slightly greater pressure is required. This matter must be given careful attention when lines of hose are run to hilltop areas which are at much greater elevations than the sprayer.

When the sprayer truck combination is not in use the pump and tank attachment can be easily removed and a commercial body attached which can be used in transporting supplies to and from the field. (Pl. VII.)

The construction of the motor-truck sprayer is of special design, owing to the double work which it is called upon to perform. As the truck must propel itself and at the same time maintain high pressure for spraying, it is necessary to have an engine transmission of extra strength, and many other parts are oversize from what would be necessary for an ordinary 3-ton truck. The chassis is of 1-inch beam construction, with platform springs and chain drive. The engine is 45–60 horsepower and has an internal governor. It has three speeds forward and one reverse, with special transfer arrangement to the pump which makes it possible to spray while traveling or standing. The controls for operating either the truck or spraying attachment are easily reached from the driver's seat. The pump is practically the same as those on horse-drawn outfits, with the exception that it is reinforced in many places to stand extra high pressures. The tank is of the U-shaped type, with a 400-gallon capacity.

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[1] Since this manuscript was prepared a more powerful truck sprayer has been designed. For this purpose a 5-ton truck with a worm drive and a pump of greater capacity has been used. This outfit is to be used in difficult spraying work in the border territory of the gipsy moth infested region.

In doing street-tree or roadside spraying, the motor truck is especially adapted, as very little time is wasted in securing water.

## POISON.

The amount of poison to be used varies with different insects, as some species will withstand more than others. In the case of the apple-tree tent caterpillar (*Malacosoma americana* Fab.) about one-half the amount of poison is required that is necessary to kill the gipsy-moth caterpillars. It is obviously wasteful to use an unnecessary amount of poison. In the case of the gipsy moth, 10 pounds of arsenate of lead and 100 gallons of water is sufficient until the caterpillars have passed the third stage; then the poison should be increased to 12½ pounds to 100 gallons of water. This increase is necessary, as the caterpillars are more resistant to poison as they grow older.

Spraying against any leaf-eating larva at the time when it is about to change to the pupal stage is not as a rule satsifactory, as very little feeding is done for a few days previous to transforming.

In purchasing arsenate of lead paste, the following specifications have been found satisfactory:

Fifty per cent actual dry arsenate of lead, not less than 15 per cent arsenic oxid ($As_2O_5$), not more than three-fourths of 1 per cent of soluble arsenates, no free acids, no adulterant or inert substances. Arsenate of lead should be in a good mechanical and physical condition and should be subjected to analysis.

These specifications carry 3 per cent more arsenic oxide ($As_2O_5$) than is required by Federal law, but much better work is done than by the weaker percentage and with more economy.

Poison carried over from one season to another in wooden containers should be tested before it is used to ascertain if it contains the proper amount of moisture, otherwise a larger amount of actual arsenate of lead may be used than is necessary.

Dry arsenate of lead has been tried on a small scale and has given good results. It has not been used extensively, as it is more expensive than the paste form.

## MIXING POISON.

Arsenate of lead in paste form can be obtained in different-size steel drums or wooden packages, and should contain 50 per cent water. The lead, being heavier than the water, readily settles at the bottom of the container and should be stirred to an even consistency before being mixed with water for spraying. If this is not properly done an uneven strength of the solution is the result and consequently spraying operations are often unsatisfactory. This is one of the parts of a spraying operation that is easiest to neglect, and in order to secure an even solution a mixer has been devised, as shown in Plate VIII. It can be attached to a 100-pound drum of arsenate of lead and the contents brought to an even consistency in from 3 to 5 minutes. The lead should be poured into another drum to make sure it is thoroughly mixed, thus increasing its efficiency and lessening the cost of labor.

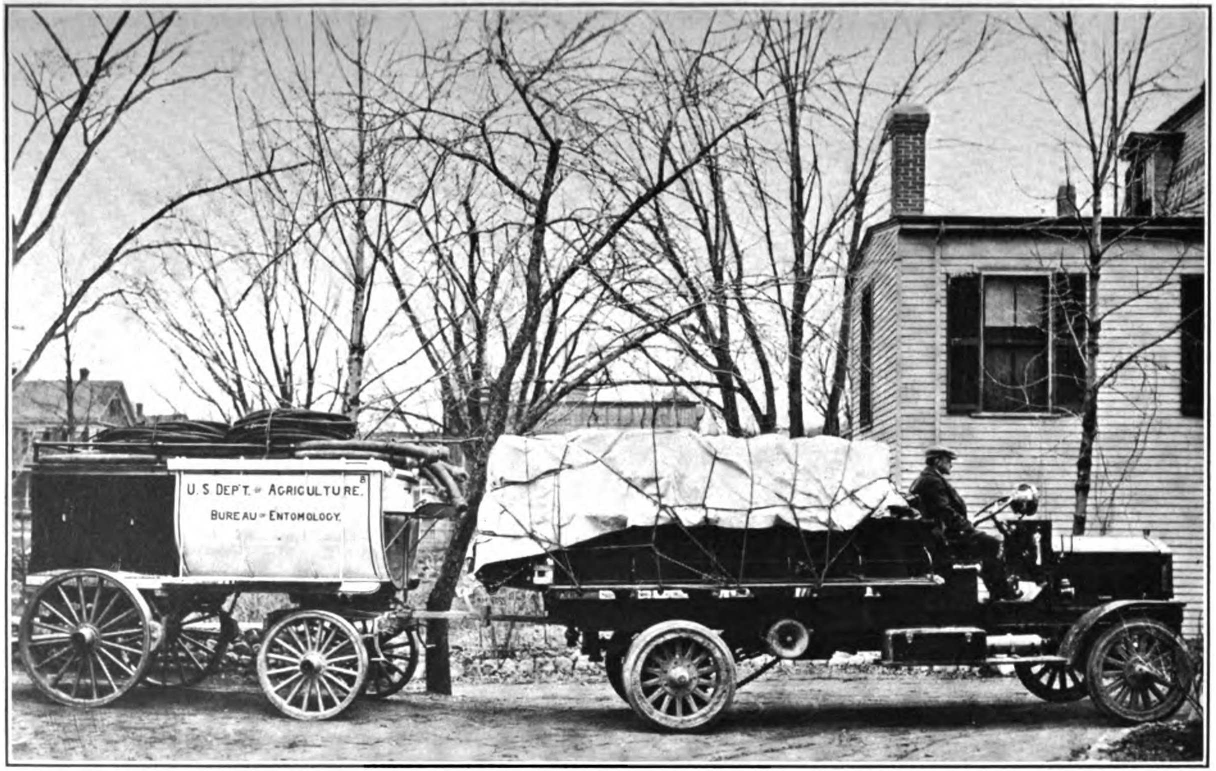
## AGITATION.

Agitation is one of the most important factors in the operation of any spraying machine, owing to the fact that if constant and thorough agitation is not maintained uneven results may be expected. In some power machines the agitator is in motion only when the pump is working, but this is not a satisfactory arrangement. If the machine is moved from one location to another and the pump is stopped a large part of the poison will settle to the bottom of the tank. It is very difficult to get arsenate of lead again into suspension, under such conditions, as it has to be sucked gradually from the bottom of the tank by the agitator, which will not function as well as if the poison is not allowed to settle.

On all machines the agitator should be directly connected with the engine and when the pump is not in use the engine should be run slowly, so as to keep the solution well mixed until the tank is empty.

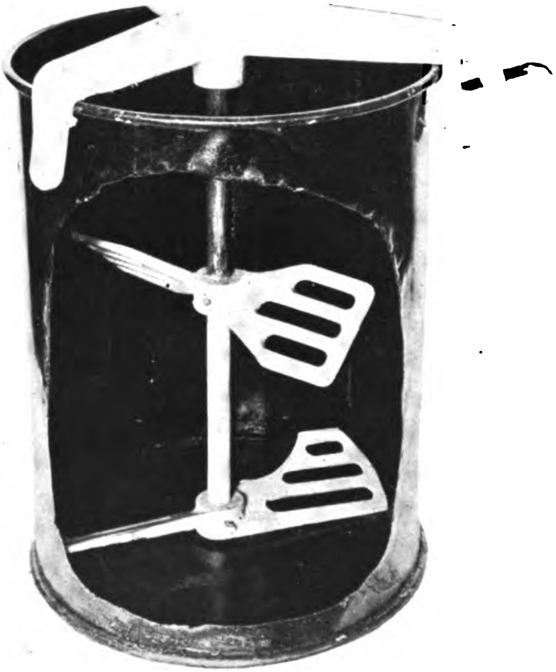
## AMOUNT OF SOLUTION TO BE USED.

The amount of solution used in solid-stream spraying should be carefully guarded, as it is very easy for considerable waste to occur. With high-power outfits using 1-inch hose and one-fourth-inch tip on the nozzle, from 25 to 35 gallons of solution is being delivered



THE MOTOR TRUCK AND PRESENT-DAY METHODS.

Motor truck used for hauling supplies and spraying outfit. Total load, four tons.



AN IMPROVED TYPE OF POISON MIXER.

Poison mixer attached to 100-pound drum, showing paddles.

every minute, and as the average shade tree contains about 3,000 square feet of foliage and 9½ gallons of solution will actually cover this amount of foliage, it is practically impossible to prevent a small amount of waste, although a much smaller percentage than would be supposed results if care is taken by the nozzleman. One-half minute of solid-stream spraying at the proper pressure will ordinarily spray the average shade tree.

There are several conditions which would cause this estimate to vary, such as high winds, location of tree, etc. In directing solid-stream spray, the force of the stream should never be allowed to strike the foliage, as the solution will not adhere, but is driven off. It should be applied in as near a mist form as possible. In the spraying of shade trees care should be taken to direct the stream so that the mist will blow or drift through the foliage. It is not always possible to spray all sides of a tree, but it can usually be completely sprayed by drifting it through or by allowing the stream to go over the tree. In spraying trees on country roadsides, where the water supply is not always easy of access, considerable time can be saved by filling the tank when there is an opportunity, even if it is not empty. If this is done an accurate method should be worked out to determine the amount of water to be added so that the proper weight of poison can be placed in the tank. Considerable time is required to secure water, even if hydrants are available.

## PRESSURES.

A knowledge of the correct pressures to use in solid-stream spraying is most essential. As has been previously stated, the solution should reach the leaves as a mist if best results are to be obtained. If this is not done much poison is wasted, and if the force of the stream is allowed to come in direct contact with the foliage it often tears and damages the leaves.

After several years experience and many experiments, it has been concluded that to obtain the best results the pressure at the nozzle when 1-inch hose is used with any sized tip should be 225 pounds in order to break the stream into a mist at the proper place.

It has been determined by tests shown in Table I that it is not practical to use over 1,500 feet of 1-inch hose with the high-power machine when a one-fourth-inch tip is used, and not over 600 feet of 1-inch hose when a five-sixteenths-inch tip is used.

**TABLE I.**—*Correct nozzle pressures for different lengths of hose and sizes of tips.*

| Length of hose. | Nozzle pressure. | Pressure at the machine. | | | |
|---|---|---|---|---|---|
| | | One-eighth inch. | Three-sixteenths inch. | One-fourth inch. | Five-sixteenths inch. |
| *Feet.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| 100 | 225 | 225 | 225 | 240 | 250 |
| 200 | 225 | 225 | 225+ | 250 | 275 |
| 300 | 225 | 225 | 230 | 260+ | 300 |
| 400 | 225 | 225 | 240− | 275+ | 325 |
| 500 | 225 | 225 | 250− | 290− | 350 |
| 600 | 225 | 225 | 250 | 305− | 400− |
| 700 | 225 | 230 | 255 | 310+ | ........... |
| 800 | 225 | 230+ | 260 | 320 | ........... |
| 900 | 225 | 235 | 265 | 330 | ........... |
| 1,000 | 225 | 235+ | 268 | 340 | ........... |
| 1,100 | 225 | 240− | 270 | 350 | ........... |
| 1,200 | 225 | 240 | 272 | 360 | ........... |
| 1,300 | 225 | 240+ | 275 | 370+ | ........... |
| 1,400 | 225 | 240+ | 278 | 390− | ........... |
| 1,500 | 225 | 245− | 280 | 410 | ........... |

The tables submitted are actual readings taken in the field, and the nearest to a 5-pound point was taken. Some of the variations can only be explained by the expansion of the rubber hose, which also explains the difference from the friction loss in 1-inch iron pipe.[1]

## EXPERIMENT TO DETERMINE THE DISTRIBUTION OF POISON ON FOLIAGE.

In order to determine how thoroughly trees were being sprayed by using the solid-stream method a number of experiments were conducted during the summer of 1916.

For this purpose a series of ferrotype plates, 14 by 10 inches, were secured and treated with black coach paint so that any spray coming in contact with them could be seen. The plates were numbered and attached to bamboo poles about 12 feet in length. This was done by splitting the small end of the pole, and after inserting the plate it was sewed in place securely with copper wire.

The plates were then placed in different positions and at different heights in trees that were to be sprayed and a record secured of the effectiveness of the work. (Pl. IX.) This is a method that can be used by anyone to test the thoroughness of spraying for leaf-eating insects.

One test was conducted to determine the time required properly to spray a shade tree when the solid-stream method is used. The tree selected was 65 feet in height, and excellent results were secured by applying the spray for half a minute. A glance at Plates X and XI shows the thoroughness of the treatment in this test and illustrates the value of this method of spraying when properly used.

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[1] See Engineering Work in Towns and Small Cities, by Ernest McCullough, 1906, p. 359. Pumping Machinery, by William M. Barr, 1908, p. 108.

## SHADE-TREE SPRAYING.

The spraying of shade trees with arsenate of lead should be accomplished at as early a date as possible after the foliage has sufficiently developed. (Pl. XII.) Early spraying not only applies to the gipsy moth, but will poison many brown-tail caterpillars, as they are much earlier feeders than the gipsy moth. In the case of the elm leaf-beetle (*Galerucella luteola* Müll.) much is accomplished in poisoning the adult beetles, which do a small amount of feeding after coming out of hibernation before mating and laying eggs, as they are very easily poisoned at that time. It is often argued that solid-stream spraying on street trees is too expensive and that the work can be done much cheaper with smaller apparatus. The principal reason for this is because of the low first cost of the smaller outfits. (Pl. XIII.) This may be true for a single year, but for two or more years the solid-stream method is the cheaper. The total cost of the most expensive high-power apparatus on the market at the present time is approximately $1,500 for a complete equipment. It is safe to figure depreciation at the rate of 20 per cent each year, although there are machines in the field at the present time that have been used 8 years and have only required an annual overhauling and the replacement of small worn parts. In 20 days' spraying one large machine should treat 10,000 shade trees. This would average only 3 cents for each tree in depreciation which is not prohibitive to any municipality. Taking everything into consideration, the entire cost of spraying shade trees with the solid stream does not exceed 12 cents per tree if the work is managed properly. The following figures are submitted to show how the cost per day is computed for 20 working days:

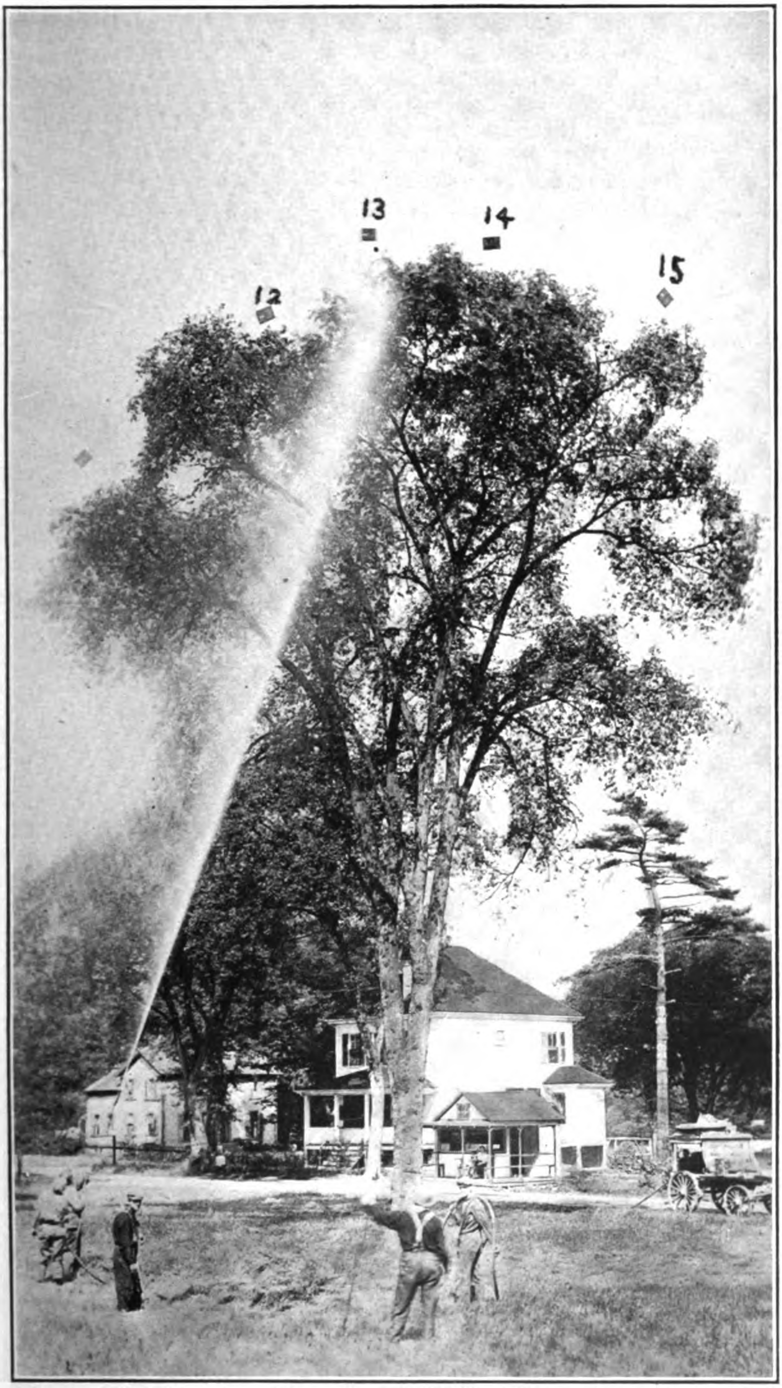
| | |
|---|---|
| 1 pair of horses and driver | $6.00 |
| 3 men, 8 hours each | 7.50 |
| 560 pounds of poison, at 5 cents per pound | 28.00 |
| 10 gallons of gasoline | 1.80 |
| 1 gallon of oil | .30 |
| Depreciation per day at 20 per cent per year | 15.00 |
| | $58.60 |

The average number of shade trees sprayed with each 400 gallons of poison is 35, and 14 tanks (5,600 gallons) in 8 hours is a good average, totaling 490 street trees per day, making the average cost per tree about 11¾ cents. In treating shade trees, where any considerable amount of spraying is to be done, the use of small outfits in mist spraying is much more expensive than the solid-stream method. In an experiment conducted during the summer of 1916 the cost of treatment with a small hand outfit was more than twice the amount per tree that it was when the solid stream was used. While one can find considerable variation in the cost of applying the mist spray, either with gasoline or hand outfits, it is more than double the cost of solid-stream spraying, which, in the long run of the season's work, will equal an amount that will more than two-thirds pay for a high-grade solid-stream machine and equipment. By following the mist method for two seasons a high-grade outfit has practically been thrown away and with no asset shown for money expended.

## WOODLAND SPRAYING.

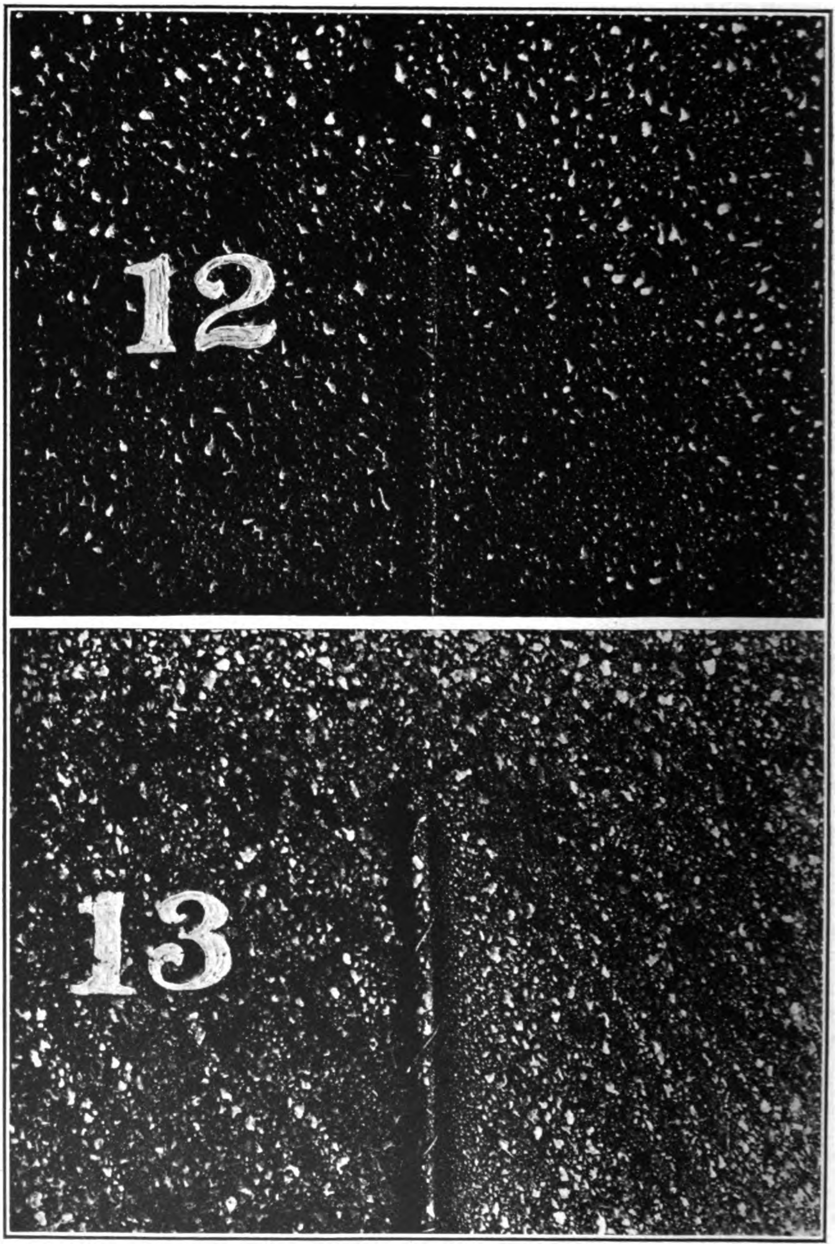
In woodland or park spraying the solid-stream method is in a class by itself, as the climbing of trees over large areas makes the mist method not only too slow but laborious and expensive. With a high-grade solid-stream machine properly equipped an average of from 12 to 15 acres can be sprayed in a day. This applies to large areas where machines can be operated without the necessity of moving any great distance in the day's work. Twenty-one acres of woodland, consisting mostly of trees 60 to 70 feet high, is the maximum treated in a single day. (Pl. XIV.) In this instance the water supply was convenient and easily accessible. The solid-stream machine for woodland spraying should be equipped with from 1,000 to 1,500 feet of 1-inch hose; 100 feet of 2½-inch suction hose, suction strainer, two nozzles (one long and one short), and with each nozzle one of the following tips: $\frac{5}{16}$, $\frac{1}{4}$, $\frac{3}{16}$, $\frac{1}{8}$ inch bores. The nozzles should be equipped with a brass spreader for spraying undergrowth and low foliage. (Pl. XV.) Hose should be provided with couplings that will not blow out—if expensive delays are to be avoided. Spraying in woodland should be arranged so that whenever possible the location of the hose may be changed while the sprayer is being filled. Much time will be lost if this is not done, and 10 men are usually necessary where long lines of hose are being used.

Men should be so located on hose lines that the nozzlemen will not be hindered by the weight of hose. The number of men needed in woodland spraying is determined entirely by the lengths of hose used. One hundred feet of 1-inch 8-ply cotton-covered hose weighs 84 pounds, and carries 4.8 gallons of water weighing 32.64 pounds, making the total weight when spraying 116.64 pounds. This makes it necessary to assign a man to every 100 feet, besides the nozzleman. The cost of woodland spraying where large areas are involved averages about $5.50 per acre. Where only small areas are sprayed the cost is much greater. Six hundred gallons of solution, when properly applied, will usually spray an acre and no climbing should be necessary. In experiments recently conducted, a pine tree 99½ feet high was successfully sprayed from the ground. Good results can usually be obtained in woodland spraying by directing the stream through the open places in the foliage in order to minimize damage



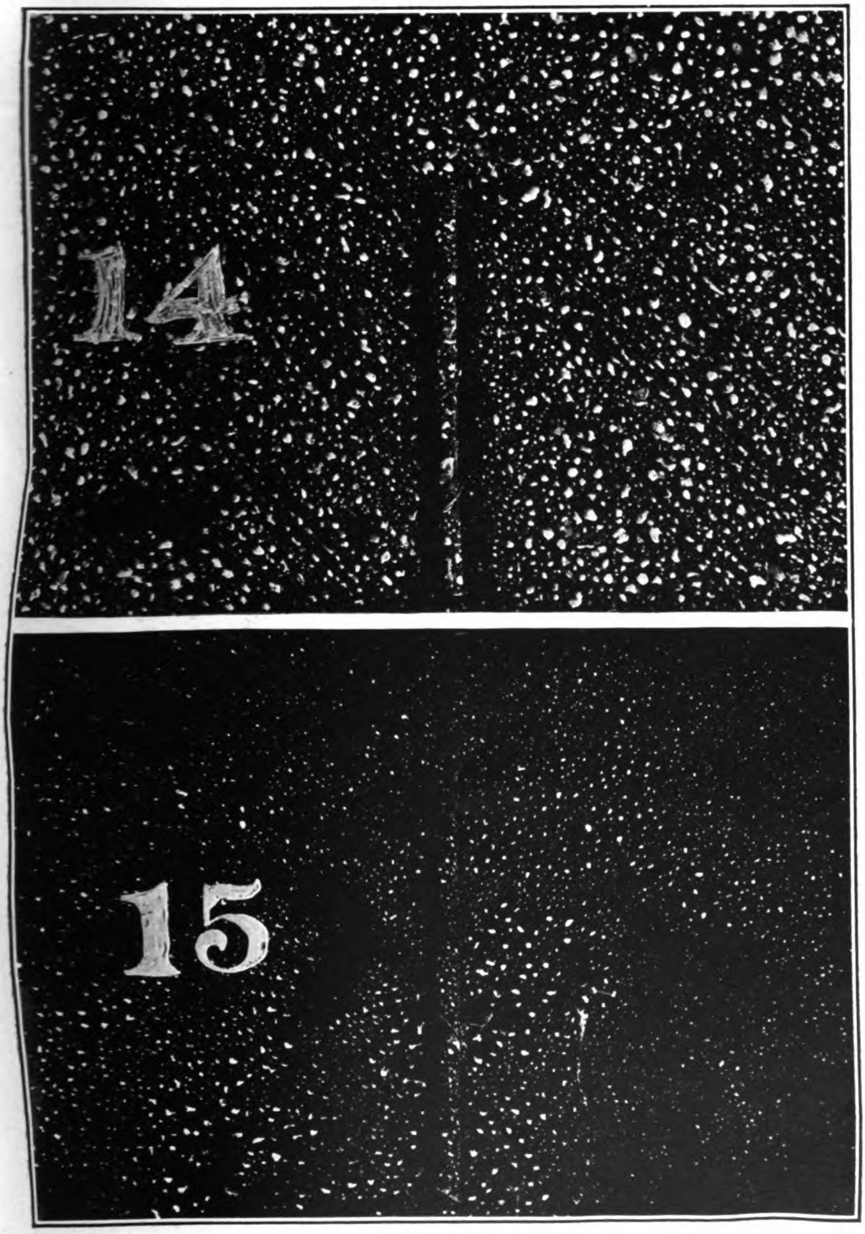
TESTING THE DISTRIBUTION OF POISON SPRAY.

Spraying elm tree 65 feet high with solid stream. Note the plates at top of tree which were used to secure a record of the distribution of the poison. (Original.)



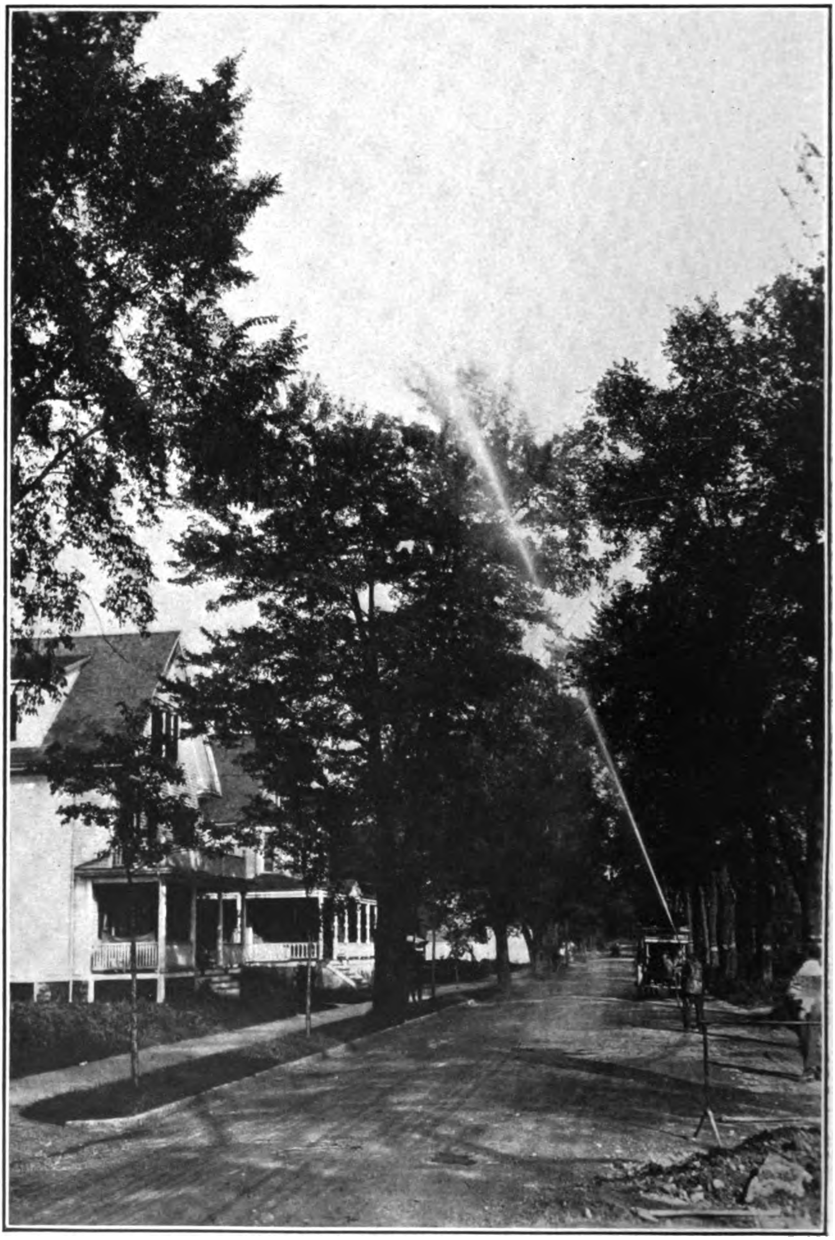
RESULTS OF TESTS FOR DISTRIBUTION OF POISON SPRAY.

Distribution of poison. Location of these plates is shown in Plate IX. (Original.)



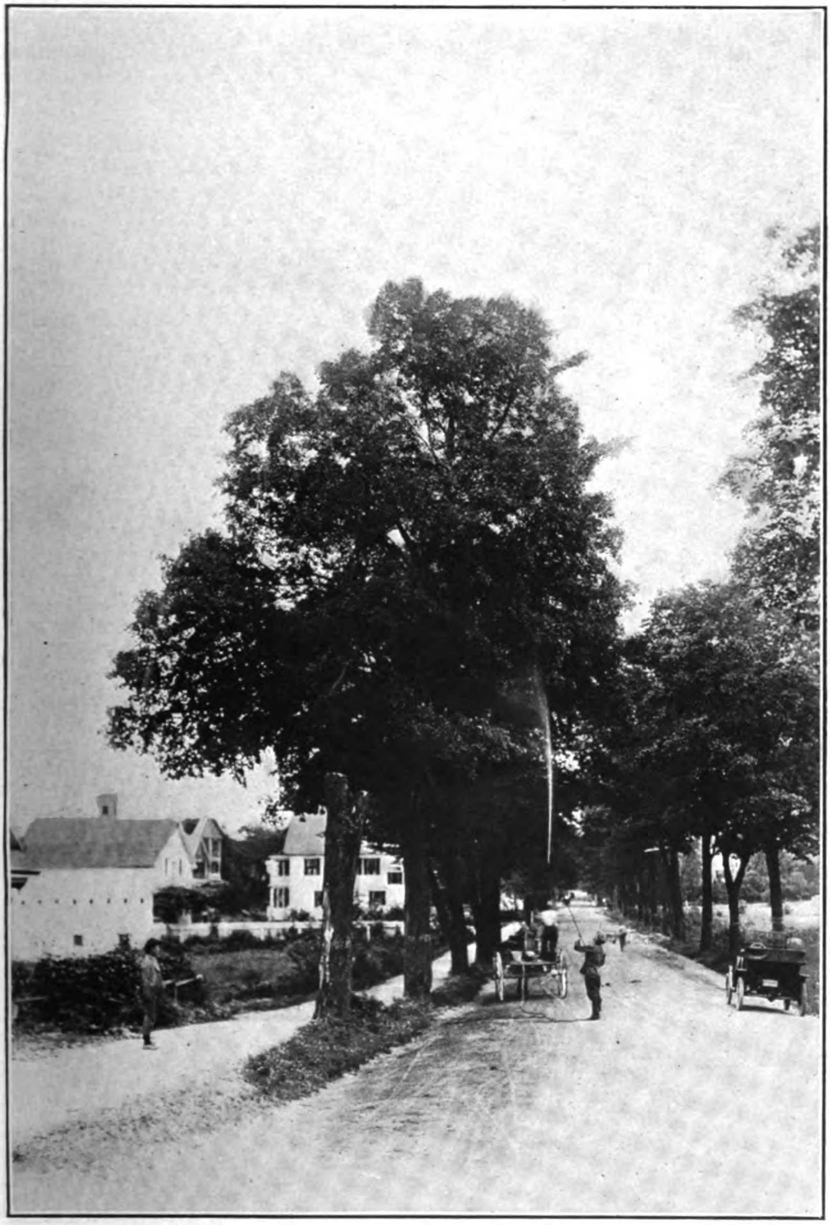
RESULTS OF TESTS FOR DISTRIBUTION OF POISON SPRAY.

Distribution of poison. Location of these plates is shown in Plate IX. (Original.)



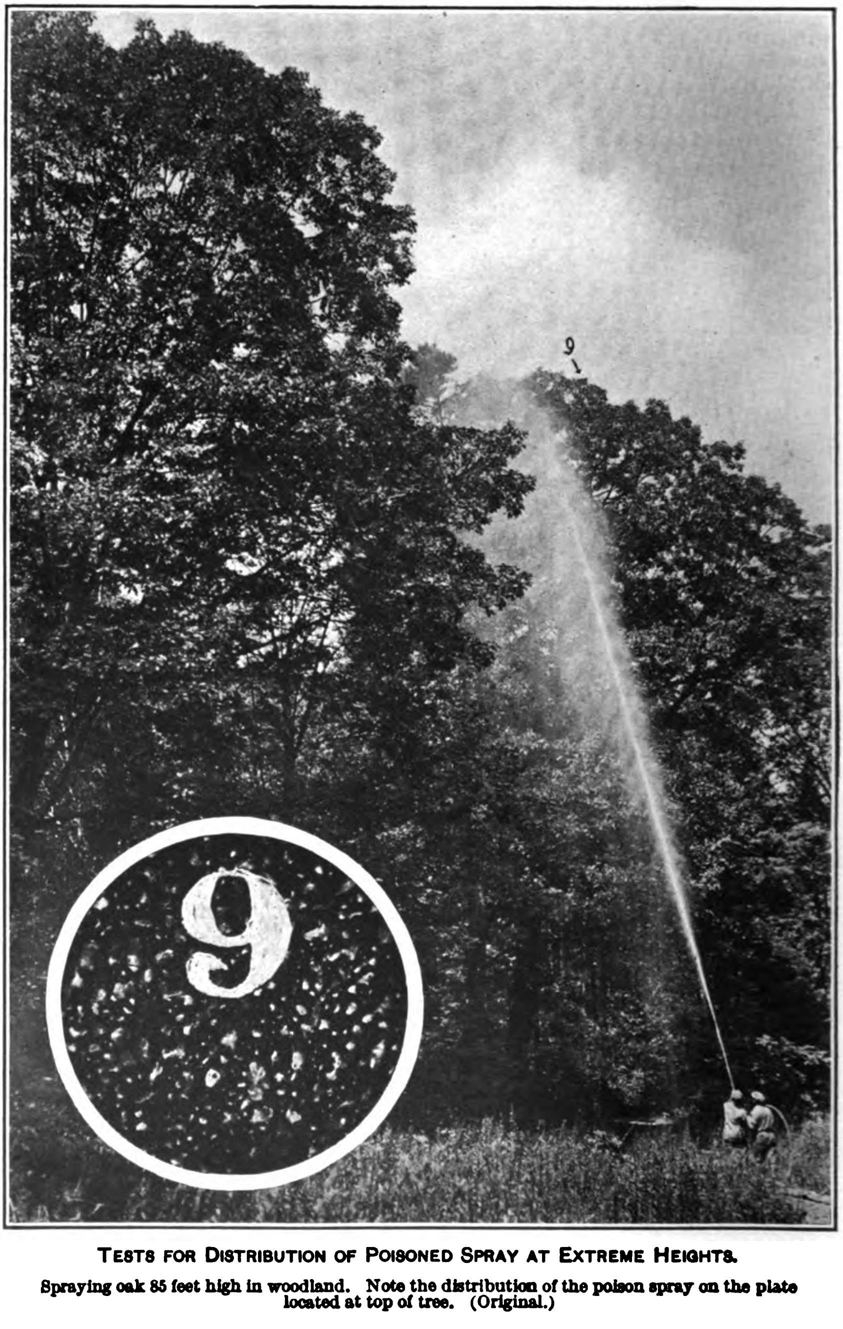
THE SOLID-STREAM SPRAYER IN OPERATION.

Spraying shade trees along the streets with solid stream. (Original.)



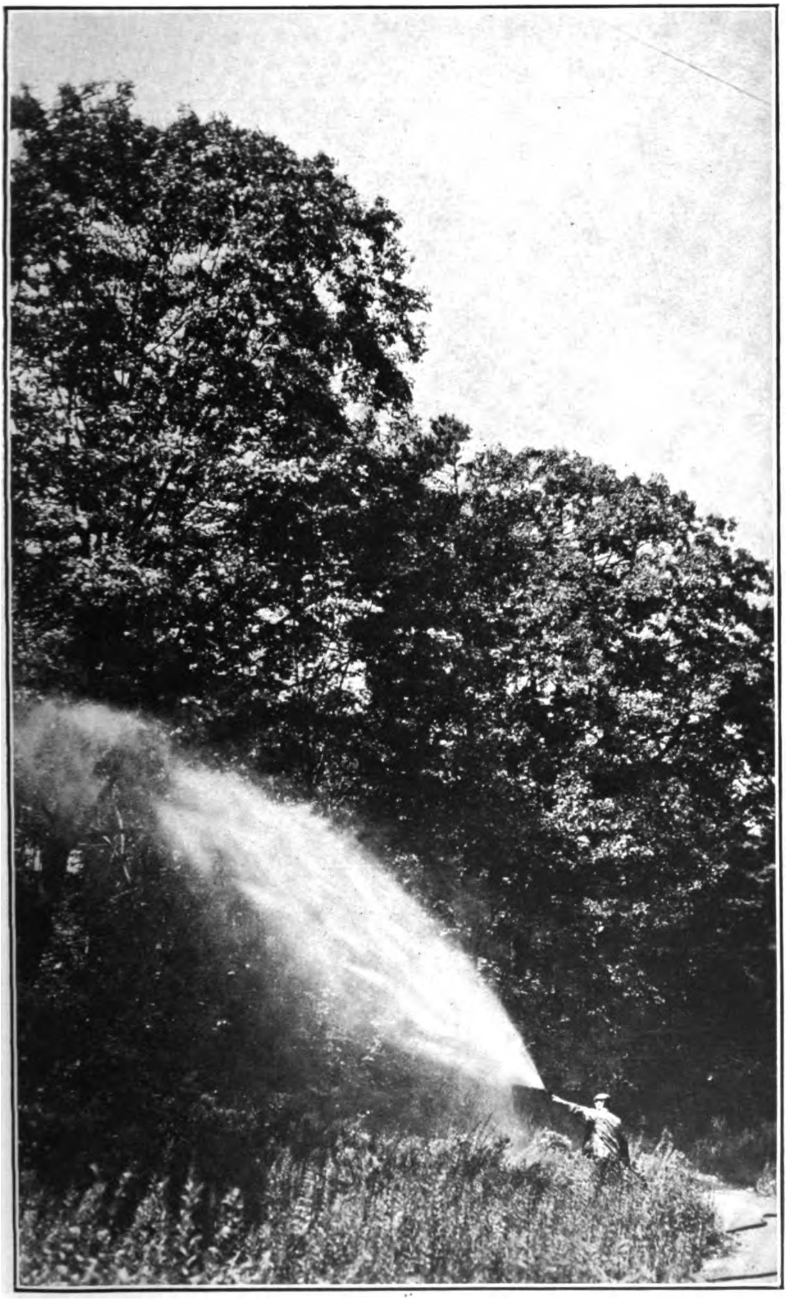
THE UNSATISFACTORY, OLD-TIME SPRAYING OPERATION WITH A HAND OUTFIT.

**Spraying shade trees with hand outfit. These trees had to be climbed in order to treat the tops. (Original.)**



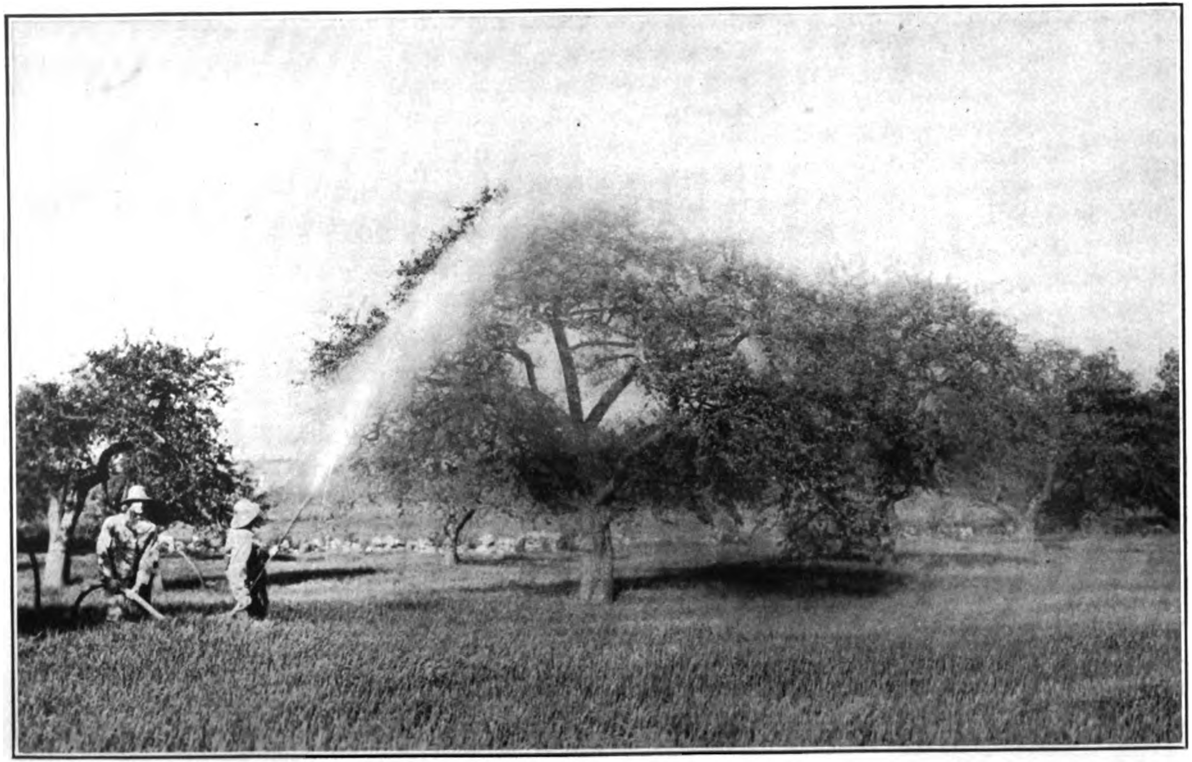
TESTS FOR DISTRIBUTION OF POISONED SPRAY AT EXTREME HEIGHTS.

Spraying oak 85 feet high in woodland. Note the distribution of the poison spray on the plate located at top of tree. (Original.)



ADAPTATION OF THE SPREADER IN SPRAYING OPERATIONS.

Spraying low growth, using spreader. (Original.)



ADAPTATION OF SPREADER TO ORCHARD-SPRAYING OPERATIONS.

Spraying orchard with solid stream, using spreader. (Original.)

to the leaves, and at the same time thoroughly treat the surrounding foliage. By using a spreader on the nozzles the lower foliage and undergrowth can be properly sprayed with much less damage or loss of solution than if the solid stream is applied. The essential thing in woodland spraying is to keep the nozzleman moving. Poison is sure to be wasted when stops are made for any length of time. Careful arrangements for water supply should be made in advance. Damming of brooks or digging holes in low ground to provide an accumulation of water will reduce the cost of spraying to a great extent. It sometimes becomes advisable in the spraying of large wooded areas to build temporary roads. This is often necessary from an economic standpoint, as the average wood road suitable for spraying machines can be built for 5 cents per square yard, and results in a great saving in the aggregate spraying cost. Especial care should be taken in the spraying of conifers, as the leaf area is very small and the stream must be broken into a fine mist in order to have the solution adhere.

## WINTER CARE OF SPRAYING MACHINES AND EQUIPMENT.

Failure to take proper care of a spraying outfit is responsible for most of the difficulties and delays that result during the spraying season. This is particularly true in regard to the precautions that should be taken when the spraying season is over and the machine is laid up for the winter. If careful attention is not given to the apparatus at this time, many difficulties and delays are likely to result during the following season.

Each machine should be taken to a convenient water supply and clear water forced through the pump and hose until both are perfectly clean. The running gear should be thoroughly washed. After this has been done the hose should be laid away for the winter. Storing hose in coils should be avoided. The machine should be properly drained of water and all metal parts coated with heavy grease. Care should be taken that all valves and petcocks are open, and the plugs and packing in the pump should be removed for the winter to allow the latter to drain. After the water has been properly drained from the engine and the circulating pipes have been disconnected the engine should be started and run for a few minutes so as to force the water out of the pump and check valves into the water jacket of the engine, where the heat will cause it to evaporate. Care should be taken not to allow the engine to become overheated while being run under the above conditions. After this has been done the spark plugs should be removed and wrapped in oiled cloth to prevent rusting. After the spark plugs have been removed, pour a cupful of cylinder oil into each cylinder and turn the engine over a few times, so that the oil may be worked in around the piston rings. Cork stoppers should be placed in the spark-plug holes to prevent moisture from entering the cylinders. The panels should be taken from both sides of the engine and all oil removed from crank case, after which the crank shaft and connecting rods should be coated with heavy grease. A few drops of light oil should be worked into all metal parts of the magneto bearing to prevent rusting.

## SUMMARY.

The subject of spraying, either solid-stream or mist spray, should be given very careful consideration, as the importance of securing good results is imperative. If they are accomplished, much more interest and cooperation may be expected in the problem of controlling leaf-eating insects. It often happens that those responsible for the results do not give sufficient attention to important details until it is too late in the season to secure the best results. One should familiarize himself with every phase of spraying, so that he may be able to cope with all conditions. While there are still those at the present time who do not feel that solid-stream spraying with arsenate of lead can be as effective as that done with smaller machines and mist nozzles, all will concede that much good work has been accomplished in the gipsy-moth area in New England with solid-stream spraying. While the solid-stream method is confined almost entirely to shade-tree and forest spraying it has been used successfully in orchards (Pl. XVI). Solid-stream work is not necessarily confined to the highest-power machines, as good results may be obtained on a small scale with medium-power machines capable of delivering a solid stream of smaller size, and which at the same time may be easily converted to mist-spray work. This also applies to the larger machines.

The problem of fighting the gipsy moth and the brown-tail moth is of such magnitude and general economic importance that it would be impossible to do the necessary spraying in the infested area with mist spray and small machines. During part of many seasons the weather is not suitable for spraying, and when conditions are right a large amount of spraying must be accomplished in a short time. The work of several boring insects which have riddled our shade trees in the past few years has also made climbing of them much more hazardous, but this must be done if the mist spray is used. If climbing is resorted to, the expense is prohibitive, especially in wooded areas.

Many times the question is asked, "Why pursue other methods of fighting the gipsy moth and the brown-tail moth; why not confine it entirely to spraying?" There are several reasons; the nature and severity of the infestation must be taken into consideration, and the proximity and danger of spread to noninfested regions. If extermination is to be expected it would not be wise to confine all efforts to spraying. If the infestation is severe and egg clusters are very numerous they should be treated with creosote prior to spraying. What is termed "rough creosoting" consists of treating the egg clusters, which can be easily reached in areas to be sprayed. In rare cases infested shade trees are located near buildings where it is impossible to spray without defacing the buildings to some extent. This can be avoided, however, if buildings are first wet with clear water. If the infestations are located in pasture lands, proper precaution should be exercised so that live stock will not be poisoned. Poison notices should be placed in conspicuous places in all locations where spraying is done.

From 800 to 1,000 tons of arsenate of lead and about 500 high-power solid-stream machines are being used each year in the New England States in fighting the gipsy moth. Thousands of acres of park and orchard trees and woodland in addition to approximately 20,000 miles of street trees are being sprayed. When spraying is properly done to control the gipsy moth, very little trouble is experienced with other leaf-eating insects.

## PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

### AVAILABLE FOR FREE DISTRIBUTION.

The Gipsy Moth and the Brown-tail Moth, with Suggestions for their Control. (Farmers' Bulletin 564.)
Report on the Gipsy Moth Work in New England. (Department Bulletin 204.)
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### FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

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Report on Field Work Against the Gipsy Moth and the Brown-tail Moth. (Entomology Bulletin 87.) Price, 35 cents.
Importation Into the United States of Parasites of the Gipsy Moth and the Brown-tail Moth: A Report of Progress, with Some Considerations of Previous and Concurrent Efforts of this Kind. (Entomology Bulletin 91.) Price, 65 cents.
Calosoma Sycophanta. Its Life History, Behavior, and Successful Colonization in New England. (Entomology Bulletin 101.) Price, 25 cents.
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UNITED STATES DEPARTMENT OF AGRICULTURE

## BULLETIN No. 481

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. ▼ May 11, 1917

# THE STATUS AND VALUE OF FARM WOODLOTS IN THE EASTERN UNITED STATES

By

E. H. FROTHINGHAM, Forest Examiner

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## WOODLOTS OF THE EASTERN STATES.

In the farming sections of the eastern States[1] the farm woodlot is a conspicuous feature. Small woodlots are almost always in sight, and sometimes fill so much of the view that they seem more extensive than the greater areas of cultivated land which are shut off by the screen of trees. In the longer settled regions and near the prairies the woodlots are relatively small and scattered; but as the topography grows rougher or a region is approached in which the farmer is really a pioneer settler, the woodlots increase in size until they become indistinguishable from the forest. The average size varies from about 5 acres in the older farming sections to 150 or 180 acres in the newer ones, such as northern Minnesota and one coast county of South Carolina. For the eastern States, as a whole, the Thirteenth Census (1910) showed the average size to be a little less than 30 acres.[2]

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[1] Except where the contrary is specified, this bulletin deals only with the States as far west as, and including, Minnesota, Iowa, Missouri, Arkansas, and Louisiana. The southern part of Florida (21 counties) is excluded.

[2] Since the statistics do not show the number of farms with woodlots and the number without, it is necessary to assume that every farm has one. As a matter of fact, there are many farms with little or no timber growth, especially in the longer-settled and the prairie regions, so that the average woodlot is really a little larger.

Considering the small size and the separate ownership of the woodlots, which has prevented their exploitation by any systematic plan such as is used in large-scale lumbering, the aggregate income which the farmers receive every year from the sale of their woodlot products is surprisingly large. In 1909,[1] for example, it amounted in the eastern States alone to nearly $170,000,000—more than the value of the entire potato crop in the East, nearly double that of the tobacco crop, and over twice that of the combined barley and rye crops. This income, however, can not be regarded as a perpetual income; it is secured very largely through the destruction of the woodlot in clearing land for cultivation. While the aggregate income from the sale of farm wood was increasing over 90 per cent between 1880 and 1910, the aggregate area of the woodlots was decreasing nearly 15 per cent, or at a rate of one-half of 1 per cent per year. A still further reduction in woodlot area must be regarded as inevitable. Although such a reduction, if carried to an extreme, would mean the loss of a convenient and cheap local timber supply for the farms, yet when the land cleared is at once devoted to raising more paying crops the removal of farm timber is entirely justifiable and desirable.

However the woodlots may be reduced in area, they will not disappear; for timber can be made an actively growing crop, often capable of yielding better returns than any other that can be grown on the poorer soils and situations of the farm. By proper management the quantity of wood products raised within a given time can be increased and the quality improved, and the woodlot can either be put on a self-sustaining basis and made to yield a few trees every year or every few years, or it can be clean-cut and reproduced at intervals of from 30 to 50 years so as to yield large returns on a relatively small investment. The farmer has a certain advantage over the lumberman who might wish to grow timber in that the funds invested in his timber are smaller in the aggregate, while the benefits to be secured are varied, and the labor that is necessary can be supplied by farm hands and teams when otherwise they would be idle. As a region becomes settled it becomes easier for the farmer to market his woodlot products profitably, because markets are more numerous and more accessible by good roads or railroads. Furthermore, the woodlot is the source of a great many indirect benefits to the farm, which are often themselves sufficient to warrant its being maintained permanently.

The purpose of this bulletin is to show as nearly as it can be done from available census statistics what the relation of the woodlot has been to the agricultural development of different parts of the East, what the tendencies appear to be, and, in general, what value the woodlot actually has to the Nation, the rural community, and the individual farm. As a means of reasonably complete and convenient assembling of the facts the farm land of the eastern United States will be considered in six divisions, each consisting of the counties having similar ratios of woodland to total farm land according to the Thirteenth Census (1910). These divisions, shown graphically on the map on pages 4 and 5, are as follows: Division I, less than 10 per cent of the total farm land wooded; Division II, from 10 to 20 per cent wooded; Division III, from 20 to 40 per cent wooded; Division IV, from 40 to 60 per cent wooded; Division V, from 60 to 80 per cent wooded; and Division VI, more than 80 per cent wooded. These divisions should not be mistaken as indicating the proportion of the total land surface which is in farms nor the general timbered condition of the region, although incidental relations between these and the proportion of farm land wooded do exist, as will be shown further on. All areas of county size or over are shown.[1] The tables in the bulletin are based on these divisions, so that the chief facts relating to the status of woodlots in any part of the Eastern States can easily be ascertained by first finding on the map in what woodlot division the area in question is located and then obtaining from the tables the data for that division and State.

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[1] Thirteenth Census.

## HOW THE GROWTH OF FARMING HAS AFFECTED THE WOODLOT.

The history of the woodlot is a part of the history of agriculture in general; the status of farming in most regions and the extent and character of the farm woodland have been so related that if one were known the other could be determined with a fair degree of accuracy. Thus in most parts of the East the early stages of farming involved a bitter struggle with the timber, and only a small area was actually cleared; then, in proportion as settlement progressed, more and more of the wooded area was claimed for cultivation, until, in the long-settled farming lands of the north central States, the woodlot is now either a mere fragment of the original forest or a new growth which has been allowed to spring up in place of the old. Meanwhile there has always been a frontier of development (as there is now in the northern parts of the Lake States) where the newly acquired farm land is still mainly woods, and as this frontier has advanced it has left behind it regions representing progressive stages in the clearing process having smaller and smaller propor-

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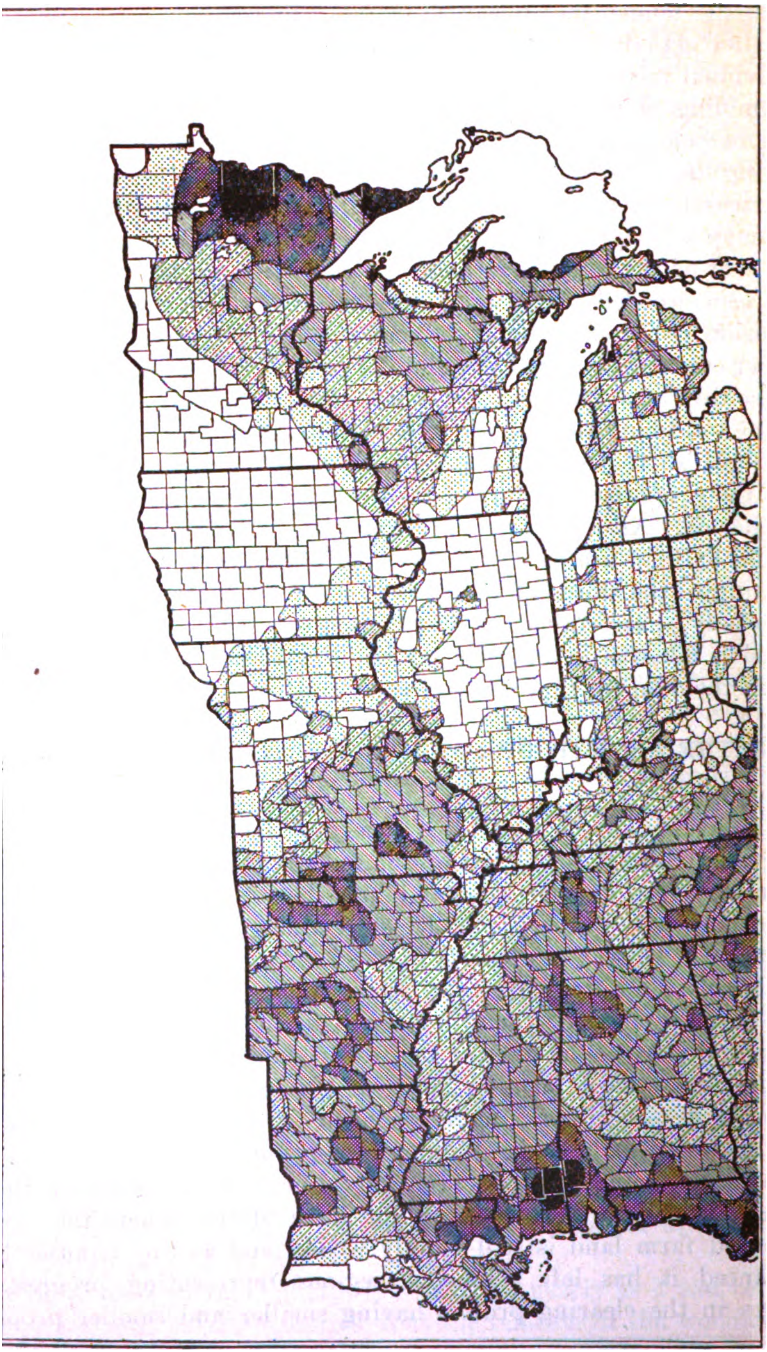
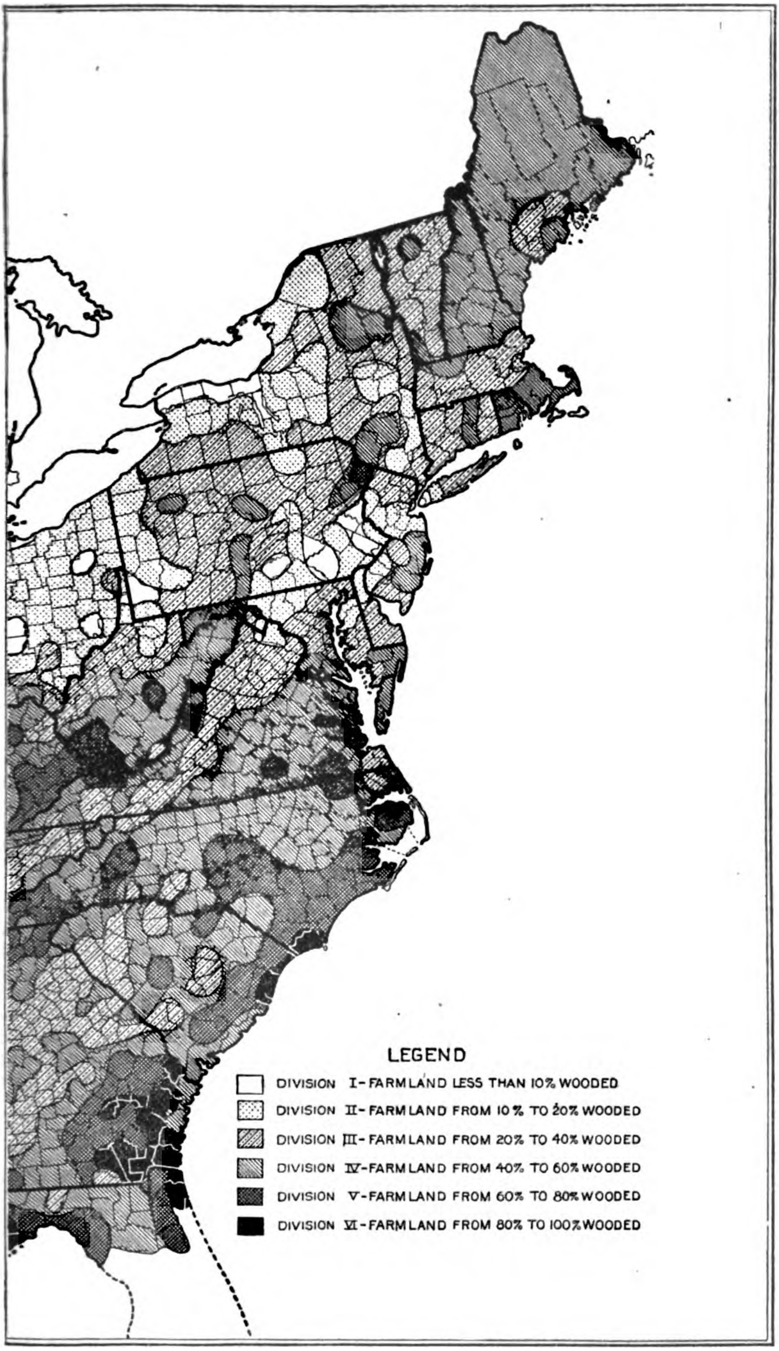
[1] The tables do not include statistics for the District of Columbia, and tables 1, 2, 3, and 5 also exclude those for counties whose location and average farm-land values showed that the land probably had a speculative value far in excess of its actual productive value for farm crops. In the aggregate this is a very small area.



. 1.—Land area of the Eastern States classified according to the proportion of farm idicate the proportion of the total land surface which is in farms (shown in Table 3) ; reas (Division I) the greatest proportion of the total land surface in farms.


LEGEND
DIVISION I - FARMLAND LESS THAN 10% WOODED
DIVISION II - FARMLAND FROM 10% TO 20% WOODED
DIVISION III - FARMLAND FROM 20% TO 40% WOODED
DIVISION IV - FARMLAND FROM 40% TO 60% WOODED
DIVISION V - FARMLAND FROM 60% TO 80% WOODED
DIVISION VI - FARMLAND FROM 80% TO 100% WOODED

**land wooded (woodlot divisions). See Table 7. The degree of shading is not meant to the black areas (Division VI) usually contain, in fact, the smallest, and the unshaded**

tions of farm land wooded.[1] Accompanying the decrease in proportion of wooded farm land there has generally been an increase in the number of farms, the proportion of the total land surface in farms, the proportion of farm land improved, and the cash value of the land.

Of the different elements by which the progress of agricultural development may be measured, such as population, value of farm property, proportion of this value which is mortgaged, aggregate crop values, etc., two have been chosen for illustration as having an important bearing on the decrease or increase of farm-woodland area in any region. These are the value of farm land and the proportion of farm land which is improved. A comparison in regard to each of these factors between "woodlot divisions" heavily and lightly wooded brings out clearly the real causes of woodlot clearing. This comparison is made in Tables 1 and 2. Table 1 gives the average land value in 1910 for the counties in each woodlot division, and Table 2 the proportion of improved land in 1880 and 1910.[2]

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[1] Exceptions which prove the rule are found in regions in which agriculture has not progressed, but has retrograded. In such cases farm woodlands have practically always increased both in actual amount and in proportion to total farm land. A notable example is New England.

[2] Extract from General Report on Agriculture, Thirteenth Census of the United States (1910), Vol. V, p. 25:

*Definitions of the classes of farm land.*—Section 8 of the Thirteenth Census act provided that the schedules relating to agriculture should call for the acreage of woodland on farms. In order that this provision might be carried into effect, definitions of farm land and of the various classes thereof were given in substantially the following form in the instructions to enumerators:

Farm land is divided into (1) improved land, (2) woodland, and (3) all other unimproved land. *Improved land* includes all land regularly tilled or mowed, land pastured and cropped in rotation, land lying fallow, land in gardens, orchards, vineyards, and nurseries, and land occupied by farm buildings. *Woodland* includes all land covered with natural or planted forest trees, which produce, or later may produce, firewood or other forest products. *All other unimproved land* includes brush land, rough or stony land, swamp land, and any other land which is not improved or in forests.

The census classification of farm land as "improved land," "woodland," and "all other unimproved land" is one not always easy for the farmers or enumerators to make. Statistics for these three classes of land may be considered fairly close approximations, but enumerators and farmers in different parts of the United States may have interpreted these definitions somewhat differently, and at the different censuses they may, even in the same locality, have put slightly different interpretations upon them.

TABLE 1.—*Average value of farm land, 1910.*

| State or State group. | Average value per acre of farm land. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Division I. | Division II. | Division III. | Division IV. | Division V. | Division VI. | Total. |
| **Eastern United States**.......... | $78.25 | $51.17 | $24.29 | $14.20 | $10.22 | $7.34 | $36.39 |
| New England.......... | [1] 14.43 | 50.70 | 22.78 | 15.62 | .......... | .......... | 19.18 |
| Middle Atlantic.......... | 61.08 | 34.42 | 23.24 | 16.67 | 13.57 | .......... | 30.77 |
| North Central.......... | 93.45 | 61.36 | 33.55 | 16.77 | 8.20 | .......... | 67.93 |
| Lake States.......... | 44.58 | 42.91 | 28.95 | 21.65 | 12.93 | 9.94 | 37.62 |
| South Atlantic.......... | 60.35 | 39.94 | 23.07 | 15.71 | 11.55 | 7.41 | 17.78 |
| South Central.......... | 44.03 | 30.72 | 19.67 | 11.23 | 8.15 | 6.63 | 16.10 |
| **New England:** | | | | | | | |
| Maine.......... | .......... | .......... | 11.55 | 14.26 | .......... | .......... | 13.73 |
| New Hampshire.......... | .......... | .......... | .......... | 13.70 | .......... | .......... | 13.70 |
| Vermont.......... | .......... | 32.28 | 12.56 | 10.64 | .......... | .......... | 12.52 |
| Massachusetts.......... | [1] 14.43 | 16.73 | 36.57 | 32.08 | .......... | .......... | 35.33 |
| Rhode Island.......... | .......... | 83.91 | 97.21 | 26.18 | .......... | .......... | 33.86 |
| Connecticut.......... | .......... | .......... | 35.86 | 17.89 | .......... | .......... | 33.03 |
| **Middle Atlantic:** | | | | | | | |
| New York.......... | 64.20 | 28.49 | 21.31 | 17.89 | .......... | .......... | 27.20 |
| New Jersey.......... | .......... | 48.12 | 47.91 | 34.05 | .......... | .......... | 47.34 |
| Pennsylvania.......... | 58.91 | 39.72 | 22.38 | 12.97 | 13.57 | .......... | 32.67 |
| **North Central:** | | | | | | | |
| Ohio.......... | 68.11 | 52.86 | 19.04 | 19.47 | .......... | .......... | 53.34 |
| Indiana.......... | 74.85 | 71.00 | 30.09 | 14.29 | .......... | .......... | 62.36 |
| Illinois.......... | 118.41 | 63.63 | 35.79 | 37.48 | .......... | .......... | 95.02 |
| Iowa.......... | 86.22 | 74.85 | 51.73 | .......... | .......... | .......... | 82.58 |
| Missouri.......... | 66.07 | 54.54 | 34.16 | 16.38 | 8.20 | .......... | 41.68 |
| **Lake States:** | | | | | | | |
| Michigan.......... | 34.74 | 35.73 | 18.68 | 15.25 | 17.41 | .......... | 32.48 |
| Wisconsin.......... | 69.08 | 64.88 | 31.65 | 22.28 | .......... | .......... | 43.30 |
| Minnesota.......... | 41.87 | 38.71 | 29.07 | 22.90 | 12.72 | 9.94 | 36.82 |
| **South Atlantic:** | | | | | | | |
| Delaware.......... | .......... | 52.62 | 28.10 | .......... | .......... | .......... | 33.63 |
| Maryland.......... | .......... | 37.64 | 38.08 | 15.21 | .......... | .......... | 32.15 |
| Virginia.......... | .......... | 36.11 | 28.04 | 15.15 | 11.67 | .......... | 20.13 |
| West Virginia.......... | 60.35 | 41.33 | 20.07 | 14.63 | 22.49 | 33.42 | 20.65 |
| North Carolina.......... | .......... | .......... | 24.38 | 16.77 | 11.08 | 4.56 | 15.29 |
| South Carolina.......... | .......... | .......... | 23.98 | 21.01 | 11.75 | 5.67 | 19.89 |
| Georgia.......... | .......... | .......... | 16.90 | 12.93 | 11.45 | 5.13 | 13.74 |
| Florida (26 northern counties).......... | .......... | .......... | 9.26 | 10.03 | 9.05 | 18.25 | 10.12 |
| **South Central:** | | | | | | | |
| Kentucky.......... | 45.74 | 36.57 | 16.62 | 8.64 | 9.31 | .......... | 21.83 |
| Tennessee.......... | .......... | 42.01 | 24.75 | 11.64 | 9.07 | .......... | 18.53 |
| Arkansas.......... | .......... | 38.70 | 24.84 | 13.54 | 6.95 | .......... | 14.13 |
| Alabama.......... | .......... | 14.92 | 11.02 | 10.47 | 7.83 | 4.81 | 10.46 |
| Mississippi.......... | .......... | 27.19 | 19.34 | 9.13 | 8.56 | 9.19 | 13.69 |
| Louisiana.......... | 29.99 | 33.05 | 23.37 | 13.58 | 8.32 | .......... | 17.99 |

[1] Nantucket Island, Mass., only.

TABLE 2.—*Proportion of farm land improved, 1910 and 1880.*

| State or State group. | Proportion of farm land improved. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Division I. | | Division II. | | Division III. | | Division IV. | | Division V. | | Division VI. | | Total. | |
| | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 |
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Eastern United States | 87.7 | 80.2 | 77.9 | 71.7 | 59.2 | 52.5 | 43.7 | 34.8 | 29.2 | 18.0 | 12.5 | 8.8 | 62.4 | 54.6 |
| New England | 40.2 | 29.8 | 65.5 | 74.5 | 39.9 | 67.8 | 33.7 | 55.3 | ........ | ........ | ........ | ........ | 36.8 | 61.2 |
| Middle Atlantic | 87.0 | 85.9 | 74.4 | 78.7 | 60.9 | 64.9 | 47.5 | 49.3 | 15.2 | 23.7 | ........ | ........ | 67.9 | 71.5 |
| North Central | 89.7 | 84.0 | 81.4 | 72.3 | 67.9 | 59.2 | 46.3 | 34.2 | 32.1 | 25.1 | ........ | ........ | 80.8 | 73.3 |
| Lake States | 82.5 | 64.0 | 71.2 | 64.6 | 51.1 | 43.6 | 34.8 | 34.3 | 14.8 | 26.3 | 7.3 | 6.0 | 65.6 | 58.0 |
| South Atlantic | 79.0 | 78.3 | 79.9 | 74.8 | 60.6 | 47.0 | 44.7 | 33.5 | 29.2 | 17.3 | 12.6 | 8.3 | 47.1 | 35.8 |
| South Central | 85.8 | 76.9 | 77.1 | 59.7 | 62.2 | 45.9 | 45.0 | 29.9 | 30.0 | 18.9 | 12.9 | 12.6 | 52.4 | 38.2 |
| New England: | | | | | | | | | | | | | | |
| Maine | ........ | ........ | ........ | ........ | 40.9 | 66.3 | 36.7 | 50.2 | ........ | ........ | ........ | ........ | 37.5 | 53.2 |
| New Hampshire | ........ | ........ | ........ | ........ | ........ | ........ | 28.6 | 62.0 | ........ | ........ | ........ | ........ | 28.6 | 62.0 |
| Vermont | ........ | ........ | 72.9 | 79.3 | 34.8 | 69.4 | 33.3 | 54.3 | ........ | ........ | ........ | ........ | 35.0 | 67.3 |
| Massachusetts | 40.2 | 29.8 | 25.9 | 54.5 | 42.6 | 66.4 | 34.3 | 55.3 | ........ | ........ | ........ | ........ | 40.4 | 63.4 |
| Rhode Island | ........ | ........ | 73.8 | 83.1 | 63.3 | 76.2 | 35.6 | 54.3 | ........ | ........ | ........ | ........ | 40.2 | 58.0 |
| Connecticut | ........ | ........ | ........ | ........ | 47.0 | 67.4 | 35.6 | 64.5 | ........ | ........ | ........ | ........ | 45.2 | 66.9 |
| Middle Atlantic: | | | | | | | | | | | | | | |
| New York | 88.0 | 86.1 | 72.0 | 80.1 | 62.5 | 70.3 | 44.2 | 50.9 | ........ | ........ | ........ | ........ | 67.4 | 74.5 |
| New Jersey | ........ | 93.4 | 78.7 | 80.4 | 60.9 | 66.1 | 46.4 | 34.5 | ........ | ........ | ........ | ........ | 70.1 | 71.6 |
| Pennsylvania | 86.3 | 85.8 | 76.7 | 76.5 | 59.0 | 58.2 | 51.7 | 49.8 | 15.2 | 23.7 | ........ | ........ | 68.2 | 67.8 |
| North Central: | | | | | | | | | | | | | | |
| Ohio | 86.8 | 79.8 | 79.6 | 73.5 | 65.3 | 62.1 | 50.1 | 50.0 | ........ | ........ | ........ | ........ | 79.8 | 73.7 |
| Indiana | 87.8 | 74.8 | 82.3 | 69.2 | 67.1 | 62.7 | 51.5 | 44.3 | ........ | ........ | ........ | ........ | 79.5 | 68.2 |
| Illinois | 90.6 | 88.8 | 81.4 | 73.9 | 70.4 | 60.4 | 55.7 | 39.9 | ........ | ........ | ........ | ........ | 86.2 | 82.5 |
| Iowa | 89.5 | 82.2 | 80.9 | 78.1 | 67.9 | 65.2 | ........ | ........ | ........ | ........ | ........ | ........ | 86.9 | 80.3 |
| Missouri | 90.8 | 78.5 | 83.2 | 69.8 | 68.3 | 54.2 | 45.8 | 32.9 | 32.1 | 25.1 | ........ | ........ | 71.1 | 60.1 |
| Lake States: | | | | | | | | | | | | | | |
| Michigan | 76.5 | 69.2 | 72.0 | 62.1 | 46.7 | 30.9 | 36.7 | 14.3 | 19.1 | ........ | ........ | ........ | 67.7 | 60.1 |
| Wisconsin | 74.6 | 82.4 | 70.6 | 69.6 | 50.9 | 47.2 | 34.0 | 33.0 | ........ | ........ | ........ | ........ | 56.5 | 59.7 |
| Minnesota | 84.8 | 55.7 | 69.6 | 65.3 | 53.3 | 40.0 | 35.9 | 44.2 | 14.5 | 26.3 | 7.3 | 6.0 | 71.0 | 54.1 |
| South Atlantic: | | | | | | | | | | | | | | |
| Delaware | ........ | ........ | 79.3 | 83.6 | 65.6 | 63.9 | ........ | ........ | ........ | ........ | ........ | ........ | 68.7 | 38.5 |
| Maryland | ........ | ........ | 80.9 | 78.8 | 67.3 | 65.5 | 50.0 | 50.6 | ........ | ........ | ........ | ........ | 66.3 | 65.3 |
| Virginia | ........ | ........ | 80.8 | 77.2 | 62.3 | 51.0 | 43.5 | 38.2 | 32.9 | 22.7 | ........ | ........ | 50.6 | 42.9 |
| West Virginia | 79.0 | 78.3 | 78.5 | 67.6 | 65.0 | 44.5 | 44.3 | 26.7 | 28.9 | 13.2 | 13.6 | 9.6 | 55.1 | 37.2 |
| North Carolina | ........ | ........ | ........ | ........ | 56.6 | 43.3 | 43.4 | 33.1 | 29.0 | 20.2 | 12.2 | 5.9 | 39.3 | 29.0 |
| South Carolina | ........ | ........ | ........ | ........ | 54.8 | 39.0 | 45.8 | 30.1 | 30.4 | 17.0 | 10.3 | 9.6 | 45.1 | 30.7 |
| Georgia | ........ | ........ | ........ | ........ | 58.7 | 43.5 | 46.1 | 31.7 | 29.1 | 12.3 | 13.0 | 8.6 | 45.6 | 31.5 |
| Florida (26 northern counties) | ........ | ........ | ........ | ........ | 63.4 | 56.8 | 47.7 | 33.3 | 24.5 | 22.0 | 11.0 | 7.3 | 39.4 | 31.5 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South Central: | | | | | | | | | | | | | | |
| Kentucky | 88.3 | 79.8 | 78.8 | 64.9 | 67.9 | 50.6 | 49.6 | 33.2 | 29.8 | 12.7 | ........ | ........ | 64.7 | 49.9 |
| Tennessee | ........ | ........ | 82.5 | 48.7 | 64.1 | 51.6 | 45.4 | 32.1 | 29.6 | 19.7 | ........ | ........ | 54.3 | 41.1 |
| Arkansas | ........ | ........ | 79.3 | 41.5 | 62.1 | 33.9 | 46.7 | 29.5 | 31.8 | 26.4 | ........ | ........ | 46.4 | 29.8 |
| Alabama | ........ | ........ | 71.8 | 59.7 | 57.2 | 42.1 | 43.1 | 28.2 | 30.1 | 18.5 | 12.5 | 13.8 | 46.8 | 33.8 |
| Mississippi | ........ | ........ | 75.6 | 44.6 | 59.8 | 41.3 | 41.8 | 27.2 | 27.1 | 19.5 | 13.5 | 12.2 | 48.5 | 32.9 |
| Louisiana | 66.0 | 36.3 | 79.7 | 50.1 | 57.6 | 38.9 | 45.7 | 31.1 | 29.1 | 18.4 | ........ | ........ | 50.5 | 33.1 |

TABLE 3.—*Proportion of total land area in farms, 1910 and 1880.*[1]

| State or State group. | Division I. | | Division II. | | Division III. | | Division IV. | | Division V. | | Division VI. | | Total. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 |
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Eastern United States | 90.5 | 72.6 | 84.7 | 79.8 | 68.2 | 63.1 | 57.3 | 51.5 | 43.2 | 37.4 | 28.2 | 22.6 | 67.8 | 60.7 |
| New England | [2]9.5 | 59.7 | 51.2 | 62.8 | 75.2 | 81.0 | 38.2 | 42.0 | ........ | ........ | ........ | ........ | 49.7 | 54.2 |
| Middle Atlantic | 83.8 | 92.8 | 81.8 | 87.3 | 59.9 | 65.3 | 39.0 | 43.8 | 49.8 | 40.2 | ........ | ........ | 67.1 | 72.7 |
| North Central | 93.7 | 78.3 | 91.9 | 88.0 | 85.7 | 76.9 | 64.1 | 44.0 | 43.8 | 14.7 | ........ | ........ | 89.0 | 78.5 |
| Lake States | 88.1 | 52.8 | 73.7 | 58.3 | 52.2 | 28.9 | 21.7 | 7.1 | 7.1 | .1 | 3.3 | (3) | 54.6 | 34.4 |
| South Atlantic | 86.9 | (4) | 89.2 | 91.8 | 78.8 | 80.5 | 71.7 | 69.6 | 51.3 | 49.3 | 37.7 | 34.3 | 67.7 | 66.7 |
| South Central | 73.7 | 71.0 | 73.7 | 69.6 | 68.2 | 63.7 | 61.3 | 53.1 | 44.7 | 35.9 | 31.6 | 14.3 | 61.6 | 54.7 |
| New England: | | | | | | | | | | | | | | |
| Maine | ........ | ........ | ........ | ........ | 82.5 | 82.7 | 28.8 | 30.2 | ........ | ........ | ........ | ........ | 32.9 | 34.2 |
| New Hampshire | ........ | ........ | ........ | ........ | ........ | ........ | 56.2 | 64.4 | ........ | ........ | ........ | ........ | 56.2 | 64.4 |
| Vermont | ........ | ........ | 93.7 | 94.2 | 85.5 | 88.4 | 55.6 | 62.9 | ........ | ........ | ........ | ........ | 79.9 | 83.6 |
| Massachusetts | [2]9.5 | 59.7 | 19.0 | 35.9 | 61.5 | 71.0 | 46.0 | 54.0 | ........ | ........ | ........ | ........ | 55.8 | 65.3 |
| Rhode Island | ........ | ........ | 64.7 | 77.2 | 62.2 | 82.9 | 65.0 | 75.0 | ........ | ........ | ........ | ........ | 64.9 | 75.4 |
| Connecticut | ........ | ........ | ........ | ........ | 71.1 | 80.0 | 69.5 | 76.6 | ........ | ........ | ........ | ........ | 70.9 | 79.5 |
| Middle Atlantic: | | | | | | | | | | | | | | |
| New York | 85.5 | 98.1 | 83.3 | 88.8 | 66.5 | 73.0 | 41.5 | 47.9 | ........ | ........ | ........ | ........ | 71.5 | 78.0 |
| New Jersey | ........ | 10.6 | 71.5 | 77.2 | 50.5 | 59.3 | 16.4 | 24.9 | ........ | ........ | ........ | ........ | 53.5 | 60.9 |
| Pennsylvania | 82.6 | 90.2 | 82.2 | 87.5 | 54.9 | 58.8 | 43.1 | 44.7 | 49.8 | 40.2 | ........ | ........ | 64.7 | 69.0 |
| North Central: | | | | | | | | | | | | | | |
| Ohio | 92.8 | 95.3 | 93.5 | 94.5 | 85.4 | 91.2 | 69.3 | 69.1 | ........ | ........ | ........ | ........ | 92.5 | 94.1 |
| Indiana | 90.9 | 81.2 | 93.4 | 89.6 | 90.4 | 90.3 | 86.6 | 78.8 | ........ | ........ | ........ | ........ | 92.3 | 88.5 |
| Illinois | 92.1 | 92.9 | 89.3 | 83.7 | 84.0 | 69.3 | 86.7 | 85.3 | ........ | ........ | ........ | ........ | 90.7 | 88.3 |
| Iowa | 95.4 | 63.4 | 95.4 | 91.2 | 94.3 | 88.1 | ........ | ........ | ........ | ........ | ........ | ........ | 95.4 | 69.6 |
| Missouri | 93.5 | 80.1 | 89.1 | 80.0 | 82.1 | 66.7 | 63.2 | 42.0 | 43.0 | 14.7 | ........ | ........ | 78.6 | 63.4 |

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[1] In Division I the portion of the land not in farms is chiefly in town and city sites, railroad rights of way, estates, factories, etc. In the other divisions the greater areas not in farms are occupied, in addition to town sites, etc., by commercial forests, brushland, cut over and burned land, swamps, sand plains, mountainous or hilly land, and other types of land of greater or less promise for agriculture. In the eastern mountains, the Lake States, and many parts of the South, small percentages of farm land indicate large amounts of standing timber, and in these sections lumbering is, for the time being at least, much more important than farming.

[2] Nantucket Island, Mass., only.

[3] Less than one-twentieth of 1 per cent.

[4] Total farm land more than recorded grand total land area.

TABLE 3.—*Proportion of total land area in farms, 1910 and 1880*—Continued.

| State or State group. | Division I. | | Division II. | | Division III. | | Division IV. | | Division V. | | Division VI. | | Total. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 |
| Lake States: | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Michigan | 85.5 | 72.4 | 71.4 | 57.0 | 30.4 | 11.9 | 8.9 | 2.5 | 5.0 | .......... | .......... | .......... | 51.5 | 37.5 |
| Wisconsin | 93.0 | 95.6 | 92.2 | 87.4 | 61.6 | 40.0 | 27.6 | 9.3 | .......... | .......... | .......... | .......... | 59.6 | 43.4 |
| Minnesota | 87.8 | 42.5 | 65.3 | 39.5 | 55.9 | 26.2 | 24.1 | 8.1 | 7.2 | .1 | 3.3 | (1) | 53.5 | 25.9 |
| South Atlantic: | | | | | | | | | | | | | | |
| Delaware | .......... | .......... | 84.2 | 91.2 | 82.2 | 85.4 | .......... | .......... | .......... | .......... | .......... | .......... | 82.6 | 86.7 |
| Maryland | .......... | .......... | 88.6 | 90.7 | 80.1 | 82.7 | 71.0 | 68.6 | .......... | .......... | .......... | .......... | 79.5 | 80.5 |
| Virginia | .......... | .......... | 94.2 | 91.9 | 76.8 | 79.6 | 75.4 | 75.2 | 67.3 | 75.5 | .......... | .......... | 75.6 | 77.0 |
| West Virginia | 86.9 | (1) | 89.1 | 93.1 | 86.4 | 81.1 | 56.1 | 60.8 | 35.1 | 35.7 | 37.8 | 30.0 | 65.2 | 66.3 |
| North Carolina | .......... | .......... | .......... | .......... | 81.6 | 84.6 | 82.2 | 78.2 | 57.4 | 61.4 | 53.0 | 64.7 | 71.9 | 71.7 |
| South Carolina | .......... | .......... | .......... | .......... | 80.0 | 83.2 | 68.9 | 72.2 | 59.7 | 47.4 | 42.8 | 47.9 | 69.2 | 69.0 |
| Georgia | .......... | .......... | .......... | .......... | 77.4 | 79.3 | 74.8 | 67.8 | 72.4 | 70.7 | 43.1 | 36.9 | 71.7 | 69.3 |
| Florida (26 northern counties) | .......... | .......... | .......... | .......... | 44.1 | 51.9 | 45.7 | 35.7 | 14.8 | 6.4 | 13.5 | 10.8 | 26.0 | 18.0 |
| South Central: | | | | | | | | | | | | | | |
| Kentucky | 92.8 | 93.5 | 91.1 | 92.7 | 88.1 | 82.0 | 81.5 | 76.7 | 76.9 | 79.7 | .......... | .......... | 86.3 | 83.6 |
| Tennessee | .......... | .......... | 74.8 | 91.3 | 87.0 | 86.5 | 70.0 | 73.1 | 46.6 | 57.3 | .......... | .......... | 75.1 | 77.5 |
| Arkansas | .......... | .......... | 37.0 | 28.6 | 48.5 | 34.3 | 54.2 | 39.5 | 47.9 | 26.5 | .......... | .......... | 51.8 | 35.9 |
| Alabama | .......... | .......... | 71.9 | 76.3 | 72.7 | 77.4 | 64.3 | 54.6 | 43.4 | 35.4 | 49.5 | 9.6 | 63.2 | 57.5 |
| Mississippi | .......... | .......... | 67.6 | 63.1 | 67.5 | 59.3 | 68.7 | 59.4 | 37.3 | 23.3 | 21.0 | 17.1 | 62.5 | 53.4 |
| Louisiana | 27.5 | 16.4 | 50.0 | 22.1 | 33.9 | 27.4 | 41.9 | 36.1 | 24.8 | 17.9 | .......... | .......... | 35.9 | 28.5 |

[1] Total farm land more than recorded grand total land area.

The general rate at which agricultural development took place between 1880 and 1910 is indicated in Table 3, which shows what proportion of the total land surface was in farms in each of these years. In New England a marked decrease took place, partly on account of the abandonment of rough, unprofitable farms. There was also a decrease in the Middle Atlantic States, and it is apparent that the States along the coast from Maine to New Jersey, having developed their farming land much earlier than the rest of the country, have tended since 1880 more toward industrial than agricultural development. Only in New England, however, has the decrease in the proportion of the total land surface in farms been accompanied by an increase in the proportion of farm land that is wooded.

### THIRTY YEARS' CHANGE IN WOODLOT AREA.

The decrease in woodlot area from 1880 to 1890 (nearly 15 per cent) was most rapid in the three divisions which now have the smallest proportion of farm land in woods. This is shown in Table 4, which gives the acreage of woodland[1] in 1910 and the percentage of increase or decrease since 1880 for each State and division. For the eastern States as a whole, the decrease amounted to 37 per cent in Division I, 39 per cent in Division II, and 18.5 per cent in Division III; while in Division IV it was only 5.7 per cent, in Division V 0.8 per cent, and in Division VI no decrease at all, but an increase of nearly 19 per cent. In New England there were increases in Divisions III and IV, due chiefly to reforestation of abandoned fields. In the Lake States the great increases which took place in Divisions III, IV, V, and VI were due to the acquisition by settlers of portions of the timberlands in these regions, which, in their new status as farm woodland, are likely to repeat the history of the woodlots in the longer-developed regions.

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[1] From the table it is easy to determine for any State or States which division has the most farm land. Thus, for the eastern States as a whole, and for New England, the South Atlantic, the South Central States, and Missouri, it is Division IV, with from 40 to 60 per cent of the farm area in woods. In Iowa it is Division I; in the Lake States, Division III; and in Ohio, Indiana, and Illinois, Division II.

TABLE 4.—*Total area of woodland on farms in 1910, and proportion of increase or decrease since 1880.*

[Minus signs in front of per cent figures indicate a decrease.]

| State or State group. | Division I. | | Division II. | | Division III. | | Division IV. | | Division V. | | Division VI. | | Total. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total woodland, 1910. | Increase or decrease since 1880. | Total woodland 1910. | Increase or decrease since 1880. | Total woodland, 1910. | Increase or decrease since 1880. | Total woodland, 1910. | Increase or decrease since 1880. | Total woodland, 1910. | Increase or decrease since 1880. | Total woodland 1910. | Increase or decrease since 1880. | Total woodland, 1910. | Increase or decrease since 1880. |
| | *Acres.* | *Per cent.* | *Acres.* | *Per cent.* | *Acres.* | *Per cent.* | *Acres.* | *Per cent.* | *Acres.* | *Per cent.* | *Acres.* | *Per cent.* | *Acres.* | *Per cent.* |
| **Eastern United States** | 4,788,676 | −37.0 | 15,640,534 | −39.0 | 39,904,925 | −18.5 | 59,366,026 | − 5.7 | 20,869,796 | − 0.8 | 2,820,666 | 18.8 | 143,391,568 | −14.9 |
| **New England** | [1] 266 | 166.0 | 19,725 | −11.7 | 3,087,587 | 11.2 | 4,745,335 | 5.1 | | | | | 7,852,913 | 7.3 |
| **Middle Atlantic** | 303,157 | −32.0 | 2,816,043 | −21.8 | 4,968,089 | −20.9 | 1,030,732 | −18.1 | 137,559 | 33.7 | | | 9,255,580 | −21.0 |
| **North Central** | 3,251,988 | −35.8 | 8,397,153 | −43.7 | 4,511,421 | −21.0 | 4,347,977 | 13.0 | 528,594 | 166.2 | | | 21,037,133 | −29.3 |
| **Lake States** | 942,600 | −24.7 | 3,137,255 | −35.6 | 5,691,286 | 32.8 | 1,948,932 | 135.5 | 424,110 | [2] 1936.4 | 83,342 | [3] 7799.6 | 12,227,525 | 8.7 |
| **South Atlantic** | 5,257 | −52.2 | 481,432 | −33.1 | 10,176,413 | −25.4 | 22,949,203 | − 9.3 | 12,046,484 | − 9.8 | 2,242,931 | 3.4 | 47,902,665 | −13.2 |
| **South Central** | 285,408 | −64.6 | 788,926 | −47.5 | 11,470,129 | −29.5 | 24,343,847 | −10.5 | 7,733,049 | 4.9 | 494,393 | 140.1 | 45,115,752 | −15.4 |
| **New England:** | | | | | | | | | | | | | | |
| Maine | | | | | 427,177 | 18.4 | 2,348,444 | 1.2 | | | | | 2,775,621 | 3.5 |
| New Hampshire | | | | | | | 1,502,389 | 15.9 | | | | | 1,502,389 | 15.9 |
| Vermont | | | 8,611 | 4.7 | 1,287,428 | 7.8 | 270,659 | −10.0 | | | | | 1,566,698 | 4.2 |
| Massachusetts | [1] 266 | 166.0 | 4,254 | −40.5 | 762,206 | 10.3 | 297,827 | − 2.7 | | | | | 1,064,553 | 6.0 |
| Rhode Island | | | 6,860 | − 1.4 | 1,974 | − 3.0 | 177,075 | 2.0 | | | | | 185,909 | 1.8 |
| Connecticut | | | | | 608,802 | 15.2 | 148,941 | 26.2 | | | | | 757,743 | 17.2 |
| **Middle Atlantic:** | | | | | | | | | | | | | | |
| New York | 108,160 | −27.0 | 1,465,436 | −15.5 | 2,314,733 | −12.7 | 547,816 | −13.7 | | | | | 4,436,145 | −14.6 |
| New Jersey | | | 207,233 | −14.6 | 277,839 | −19.4 | 52,924 | −56.1 | | | | | 537,996 | −24.0 |
| Pennsylvania | 194,997 | −34.4 | 1,143,374 | −29.6 | 2,375,517 | −27.6 | 429,992 | −14.6 | 137,559 | 33.7 | | | 4,281,439 | −26.3 |
| **North Central:** | | | | | | | | | | | | | | |
| Ohio | 373,771 | −56.1 | 2,430,088 | −45.6 | 364,183 | −32.4 | 117,334 | − 3.5 | | | | | 3,285,376 | −45.1 |
| Indiana | 229,099 | −58.3 | 1,858,305 | −50.2 | 1,192,733 | −23.1 | 90,654 | −14.3 | | | | | 3,370,791 | −43.2 |
| Illinois | 1,137,685 | −35.7 | 1,500,469 | −40.9 | 452,888 | −17.4 | 56,837 | −29.6 | | | | | 3,147,879 | −36.2 |
| Iowa | 1,172,028 | − 4.4 | 795,593 | −27.0 | 346,494 | −21.2 | | | | | | | 2,314,115 | −16.0 |
| Missouri | 339,405 | −49.2 | 1,812,698 | −41.4 | 2,155,123 | −18.2 | 4,083,152 | 15.3 | 528,594 | 166.2 | | | 8,918,972 | −12.0 |
| **Lake States:** | | | | | | | | | | | | | | |
| Michigan | 209,209 | −53.9 | 1,698,043 | −46.6 | 783,836 | 11.0 | 216,211 | 88.6 | [4] 20,255 | (4) | | | 2,927,554 | −34.2 |
| Wisconsin | 204,052 | −43.8 | 755,023 | −36.4 | 3,218,429 | 20.1 | 1,200,076 | 123.0 | | | | | 5,377,580 | 12.8 |
| Minnesota | 529,339 | 21.5 | 684,189 | 33.8 | 1,689,021 | 87.8 | 532,645 | 204.4 | 403,855 | [2] 1936.4 | 83,342 | [3] 7799.6 | 3,922,391 | 93.2 |
| **South Atlantic:** | | | | | | | | | | | | | | |
| Delaware | | | 27,849 | 5.4 | 224,183 | −11.3 | | | | | | | 252,032 | − 9.7 |
| Maryland | | | 206,551 | −18.2 | 693,231 | −12.9 | 567,551 | − 3.1 | | | | | 1,467,333 | −10.2 |
| Virginia | | | 72,486 | −13.9 | 2,365,849 | −27.3 | 5,345,155 | 4.9 | 630,245 | − 9.5 | | | 8,414,680 | − 7.8 |
| West Virginia | 5,257 | −52.2 | 174,546 | −51.1 | 1,187,359 | −39.3 | 2,110,784 | −35.8 | 882,039 | −19.5 | 108,851 | 19.4 | 3,968,836 | −35.8 |
| North Carolina | | | | | 491,309 | −28.1 | 6,981,574 | − 3.7 | 4,752,074 | −15.6 | 226,782 | −25.6 | 12,451,739 | −10.2 |
| South Carolina | | | | | 1,513,210 | −16.5 | 2,866,349 | −20.7 | 1,773,671 | 10.2 | 185,912 | −14.6 | 6,339,142 | −12.6 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Georgia | ........ | ........ | ........ | ........ | 3,648,182 | −24.3 | 4,052,920 | − 8.6 | 3,738,806 | −18.6 | 1,562,748 | 9.7 | 13,003,741 | −14.8 |
| Florida (26 northern counties) | ........ | ........ | ........ | ........ | 53,090 | −27.0 | 1,024,870 | ........ | 769,559 | 121.0 | 158,643 | 21.3 | 2,006,162 | 27.2 |
| South Central: | | | | | | | | | | | | | | |
| Kentucky | 261,821 | −66.2 | 405,431 | −49.5 | 2,178,341 | −33.6 | 2,555,184 | −20.7 | 1,550,849 | −23.3 | ........ | ........ | 6,951,626 | −31.2 |
| Tennessee | ........ | ........ | 9,147 | −74.9 | 3,205,625 | −30.9 | 3,831,288 | −25.6 | 961,673 | −31.5 | ........ | ........ | 8,007,733 | −28.7 |
| Arkansas | ........ | ........ | 25,186 | −56.0 | 835,467 | −24.1 | 5,507,455 | 1.2 | 2,143,402 | 70.3 | ........ | ........ | 8,511,510 | 8.3 |
| Alabama | ........ | ........ | 168,049 | −40.9 | 2,012,514 | −28.2 | 5,532,924 | − 5.5 | 1,436,641 | .3 | 294,636 | 462.4 | 9,444,764 | − 9.5 |
| Mississippi | ........ | ........ | 109,095 | −58.3 | 2,217,800 | −29.7 | 4,463,158 | − 9.7 | 893,748 | 41.0 | 199,757 | 30.1 | 7,883,558 | −13.8 |
| Louisiana | 23,587 | −26.4 | 72,018 | 20.7 | 1,020,382 | −20.0 | 2,453,838 | − 4.5 | 746,736 | 20.3 | ........ | ........ | 4,316,561 | − 5.3 |

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[1] Nantucket Island only.

[2] Increase is for St. Louis County, Minn., only; total area (1910) is for Beltrami, Itasca ,and St. Louis counties.

[3] Increase is for Cook County, Minn., only; total area (1910) is for Cook and Koochiching counties.

[4] In Michigan the only county in Division V was Alger County, which had not been organized in 1880.

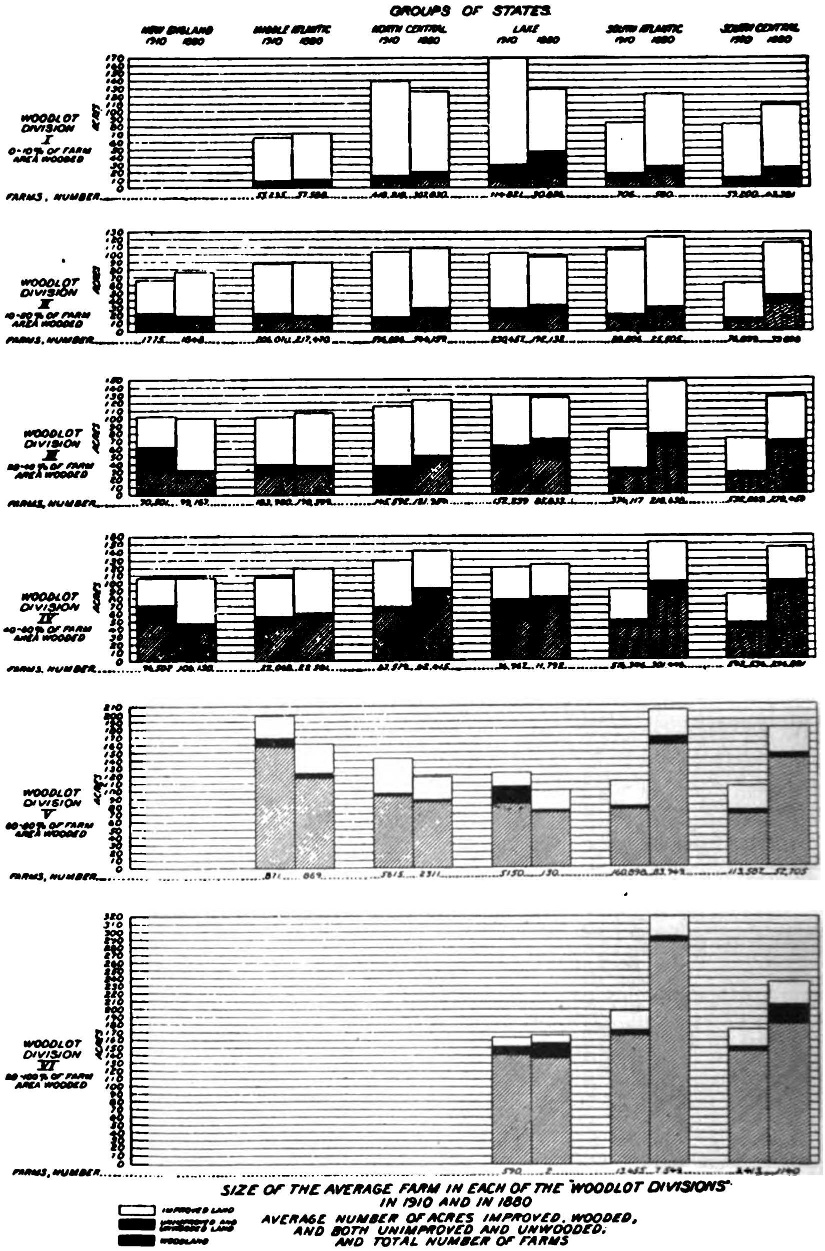
GROUPS OF STATES
NEW ENGLAND 1910 1880
MIDDLE ATLANTIC 1910 1880
NORTH CENTRAL 1910 1880
LAKE 1910 1880
SOUTH ATLANTIC 1910 1880
SOUTH CENTRAL 1910 1880
ACRES
WOODLOT DIVISION I 0-10% OF FARM AREA WOODED
WOODLOT DIVISION II 10-20% OF FARM AREA WOODED
WOODLOT DIVISION III 20-40% OF FARM AREA WOODED
WOODLOT DIVISION IV 40-60% OF FARM AREA WOODED
WOODLOT DIVISION V 60-80% OF FARM AREA WOODED
WOODLOT DIVISION VI 80-100% OF FARM AREA WOODED
FARMS, NUMBER
SIZE OF THE AVERAGE FARM IN EACH OF THE "WOODLOT DIVISIONS"
IN 1910 AND IN 1880
AVERAGE NUMBER OF ACRES IMPROVED, WOODED,
AND BOTH UNIMPROVED AND UNWOODED;
AND TOTAL NUMBER OF FARMS
IMPROVED LAND
UNIMPROVED AND UNWOODED LAND
WOODLAND

FIG. 2.

In every State, except Minnesota and Massachusetts (Nantucket Island), there was a decrease in Division I; four States showed increases in Division II and two showed a marked falling off in Division VI.[1] In most of the States the decrease was more rapid in the small woodlot than in the large woodlot regions. In Iowa, where over half the farm woodland is in Division I, the reverse was the case; the decrease in Division I was only 4.4 per cent, while in the other two divisions represented it was 27 and 21.2 per cent, respectively. This would indicate that in Iowa the farmers appreciate the value of small woodlots more than in many other States. It is partly accounted for by the planting of prairie windbreaks and tree plantations.

Though the decrease in woodland has been caused chiefly by the need of land for cultivation or grazing, a great deal of farm land has been left unimproved when cleared. The area of unimproved unwooded farm land in the Eastern States, according to the census of 1910, is 40,429,951 acres,[2] or about 8 per cent of all farm land. Between 1880 and 1910 this land increased over 34 per cent in amount, while the increase in total farm holdings was less than 12 per cent. It is true that some of this increase, especially in regions like the northern part of the Lake States, can be accounted for by the acquisition by farmers of stump lands not yet in shape for cultivation. Some of it may be used for grazing, but not a large amount, for in taking the census statistics pasture land was usually classed as "improved." In the East, as a whole, it is probable that the greater part of this class of land has remained idle, partly because the farmer did not have the means to improve it and partly because it was too poorly drained, too steep, or too stony for successful cultivation.

The acreage of unimproved and unwooded land in 1910, its proportion to the total area of farm land, and the proportionate increase or decrease since 1880 are shown for each State and division in Table 5.

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[1] As is indicated by the blank spaces in the table, in some States there are no areas of county size in several of the divisions.

[2] This is the net amount after making the deduction referred to in the footnote on p. 8. The aggregate area of unimproved and unwooded farm land in these States, as given in the census of 1910, is 40,779,673 acres.

**Table 5.**—*Farm land unimproved and unwooded in 1910, and proportion of increase or decrease since 1880.*

[Minus signs in front of per cent figures indicate a decrease.]

| State or State groups. | Division I. | | | Division II. | | |
|---|---|---|---|---|---|---|
| | Unimproved and unwooded land, 1910. | | Increase or decrease since 1880 (per cent). | Unimproved and unwooded land, 1910. | | Increase or decrease since 1880 (per cent). |
| | Acres. | Per cent of total farm land. | | Acres. | Per cent of total farm land. | |
| Eastern United States | 5,757,569 | 6.7 | − 3.9 | 9,161,884 | 8.1 | 116.0 |
| New England | [1] 1,593 | 51.2 | − 88.3 | 20,337 | 18.0 | 44.5 |
| Middle Atlantic | 164,819 | 4.6 | 83.4 | 1,868,968 | 10.2 | 241.5 |
| North Central | 2,731,269 | 4.7 | 1.6 | 3,172,487 | 5.1 | 103.7 |
| Lake | 2,453,616 | 12.6 | − 16.2 | 3,648,043 | 15.5 | 113.5 |
| South Atlantic | 7,242 | 12.2 | 70.8 | 130,740 | 4.3 | 94.3 |
| South Central | 399,030 | 8.3 | 48.2 | 321,309 | 6.6 | − 7.7 |
| New England: [2] | | | | | | |
| Vermont | ........ | ........ | ........ | 4,866 | 9.8 | 128.6 |
| Massachusetts | [1] 1,593 | 51.2 | − 88.3 | 9,974 | 59.7 | 6.5 |
| Rhode Island | ........ | ........ | ........ | 5,497 | 11.7 | 113.5 |
| Middle Atlantic: | | | | | | |
| New York | 68,512 | 4.7 | 18.5 | 1,244,867 | 12.9 | 283.9 |
| New Jersey | ........ | ........ | ........ | 96,836 | 6.8 | 61.2 |
| Pennsylvania | 96,307 | 4.5 | 201.4 | 527,265 | 7.3 | 228.7 |
| North Central: | | | | | | |
| Ohio | 232,197 | 5.0 | 137.6 | 1,202,252 | 6.8 | 298.9 |
| Indiana | 107,664 | 3.9 | 44.4 | 599,256 | 4.3 | 65.5 |
| Illinois | 698,511 | 3.6 | 60.7 | 557,635 | 5.0 | 244.1 |
| Iowa | 1,587,121 | 6.0 | − 14.8 | 392,288 | 6.3 | 87.6 |
| Missouri | 105,776 | 2.2 | − 51.7 | 421,056 | 8.2 | − 18.8 |
| Lake: | | | | | | |
| Michigan | 344,117 | 18.9 | 118.1 | 2,008,239 | 15.2 | 142.2 |
| Wisconsin | 443,236 | 17.4 | 359.4 | 796,925 | 15.1 | 137.2 |
| Minnesota | 1,666,263 | 11.5 | − 37.6 | 847,879 | 16.8 | 55.4 |
| South Atlantic: [2] | | | | | | |
| Delaware | ........ | ........ | ........ | 20,729 | 8.8 | 37.1 |
| Maryland | ........ | ........ | ........ | 37,226 | 2.9 | 58.9 |
| Virginia | ........ | ........ | ........ | 7,500 | 1.8 | − 9.3 |
| West Virginia | 7,242 | 12.2 | 70.8 | 65,285 | 5.9 | 218.4 |
| South Central: | | | | | | |
| Kentucky | 243,537 | 5.6 | 139.4 | 126,833 | 5.0 | 40.9 |
| Tennessee | ........ | ........ | ........ | 1,063 | 1.8 | 785.8 |
| Arkansas | ........ | ........ | ........ | 3,346 | 2.4 | − 35.4 |
| Alabama | ........ | ........ | ........ | 110,406 | 11.2 | − 20.4 |
| Mississippi | ........ | ........ | ........ | 37,484 | 6.2 | − 23.7 |
| Louisiana | 155,493 | 20.5 | − 7.2 | 42,177 | 7.5 | − 34.9 |

[1] Nantucket Island.

[2] The States in this group in which woodlot Divisions I and II are not represented are omitted.

**Table 5.**—*Farm land unimproved and unwooded in 1910, and proportion of increase or decrease since 1880*—Continued.

[Minus signs in front of per cent figures indicate a decrease.]

| State or State group. | Division III. | | | Division IV. | | |
|---|---|---|---|---|---|---|
| | Unimproved and unwooded land, 1910. | | Increase or decrease since 1880 (per cent). | Unimproved and unwooded land, 1910. | | Increase or decrease since 1880 (per cent). |
| | Acres. | Per cent of total farm land. | | Acres. | Per cent of total farm land. | |
| Eastern United States | 14,474,688 | 10.8 | 50.4 | 9,701,982 | 7.9 | 7.8 |
| New England | 2,457,056 | 26.6 | 486.1 | 2,127,359 | 20.5 | 271.4 |
| Middle Atlantic | 2,269,509 | 12.2 | 181.6 | 224,047 | 9.4 | 116.3 |
| North Central | 850,417 | 5.1 | 111.1 | 365,004 | 4.1 | 221.0 |
| Lake | 3,898,289 | 9.9 | 112.2 | 942,313 | 21.2 | 604.8 |
| South Atlantic | 2,216,915 | 7.0 | −33.9 | 3,100,898 | 6.6 | −39.4 |
| South Central | 2,782,502 | 7.4 | −.8 | 2,942,361 | 5.1 | −.7 |
| New England: | | | | | | |
| Maine | 294,037 | 24.1 | 472.6 | 866,544 | 17.0 | 159.4 |
| New Hampshire | ........ | ........ | ........ | 817,884 | 25.2 | 601.9 |
| Vermont | 1,316,547 | 33.0 | 1,730.3 | 141,501 | 22.9 | 660.8 |
| Massachusetts | 477,612 | 22.1 | 225.6 | 156,939 | 22.6 | 175.2 |
| Rhode Island | 1,529 | 16.0 | 54.3 | 72,029 | 18.6 | 139.3 |
| Connecticut | 367,331 | 19.9 | 147.8 | 72,462 | 21.1 | 340.6 |
| Middle Atlantic: | | | | | | |
| New York | 1,211,569 | 12.9 | 196.8 | 152,646 | 12.1 | 98.9 |
| New Jersey | 120,151 | 11.8 | 101.4 | 14,878 | 11.8 | 167.0 |
| Pennsylvania | 937,789 | 11.6 | 177.5 | 56,523 | 5.6 | 165.6 |
| North Central: | | | | | | |
| Ohio | 137,270 | 9.5 | 193.7 | 20,644 | 7.4 | 29.6 |
| Indiana | 278,141 | 6.2 | 145.8 | 12,719 | 5.9 | 509.4 |
| Illinois | 64,496 | 3.7 | 181.4 | 6,093 | 4.3 | 87.9 |
| Iowa | 145,965 | 9.5 | 147.5 | ........ | ........ | ........ |
| Missouri | 224,545 | 3.0 | 39.5 | 325,548 | 4.0 | 252.2 |
| Lake: | | | | | | |
| Michigan | 729,325 | 25.7 | 1,055.5 | 100,660 | 20.1 | 1,462.6 |
| Wisconsin | 1,939,382 | 18.5 | 111.6 | 595,337 | 21.9 | 707.4 |
| Minnesota | 1,229,582 | 19.7 | 43.3 | 246,316 | 20.3 | 360.2 |
| South Atlantic: | | | | | | |
| Delaware | 52,567 | 6.5 | 7.1 | ........ | ........ | ........ |
| Maryland | 122,642 | 4.9 | 33.8 | 74,806 | 5.9 | 167.0 |
| Virginia | 314,745 | 4.4 | −12.7 | 858,331 | 7.8 | −48.7 |
| West Virginia | 168,927 | 4.4 | 172.6 | 283,239 | 6.6 | 130.7 |
| North Carolina | 92,948 | 6.9 | −14.9 | 819,405 | 5.9 | −46.0 |
| South Carolina | 495,835 | 11.2 | −51.0 | 468,840 | 7.6 | −47.2 |
| Georgia | 961,916 | 8.7 | −41.9 | 499,057 | 6.0 | −37.3 |
| Florida (26 northern counties) | 7,335 | 4.4 | −34.9 | 97,221 | 4.5 | 5.4 |
| South Central: | | | | | | |
| Kentucky | 289,914 | 3.7 | 17.2 | 179,709 | 3.3 | −2.7 |
| Tennessee | 634,138 | 5.9 | 27.3 | 451,252 | 5.8 | 9.0 |
| Arkansas | 123,996 | 4.9 | 50.9 | 582,721 | 5.1 | 36.5 |
| Alabama | 640,146 | 10.3 | −37.1 | 690,488 | 6.3 | −15.0 |
| Mississippi | 716,177 | 10.2 | 17.1 | 818,326 | 9.0 | 6.0 |
| Louisiana | 378,131 | 11.5 | 8.0 | 219,865 | 4.5 | −37.6 |

TABLE 5.—*Farm land unimproved and unwooded in 1910, and proportion of increase or decrease since 1880*—Continued.

[Minus signs in front of per cent figures indicate a decrease.]

| State or State group. | Division V. | | | Division VI. | | | Total. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Unimproved and unwooded land, 1910. | | Increase or decrease since 1880 (per cent). | Unimproved and unwooded land, 1910. | | Increase or decrease since 1880 (per cent). | Unimproved and unwooded land, 1910. | | Increase or decrease since 1880 (per cent). |
| | Acres. | Per cent of total farm land. | | Acres. | Per cent of total farm land. | | Acres. | Per cent of total farm land. | |
| Eastern United States | 1,226,790 | 3.9 | 7.6 | 107,038 | 3.2 | 50.3 | 40,429,951 | 8.2 | 34.4 |
| New England | ...... | ...... | ...... | ...... | ...... | ...... | 4,606,345 | 23.4 | 351.8 |
| Middle Atlantic | 9,515 | 5.5 | 139.9 | ...... | ...... | ...... | 4,536,858 | 10.5 | 192.6 |
| North Central | 13,324 | 1.7 | 150.4 | ...... | ...... | ...... | 7,132,501 | 4.8 | 49.6 |
| Lake | 116,925 | 18.4 | 40,499.0 | 6,575 | 6.8 | 16,759.0 | 11,065,761 | 16.3 | 67.5 |
| South Atlantic | 590,299 | 3.3 | − 28.6 | 81,075 | 3.0 | 88.0 | 6,127,169 | 6.0 | − 34.9 |
| South Central | 496,727 | 4.2 | 63.2 | 19,388 | 3.3 | − 30.9 | 6,961,317 | 6.4 | 3.6 |
| **New England:** | | | | | | | | | |
| Maine | ...... | ...... | ...... | ...... | ...... | ...... | 1,160,581 | 18.4 | 201.2 |
| New Hampshire | ...... | ...... | ...... | ...... | ...... | ...... | 817,884 | 25.2 | 601.9 |
| Vermont | ...... | ...... | ...... | ...... | ...... | ...... | 1,462,914 | 31.4 | 1,478.8 |
| Massachusetts | ...... | ...... | ...... | ...... | ...... | ...... | 646,118 | 22.6 | 185.0 |
| Rhode Island | ...... | ...... | ...... | ...... | ...... | ...... | 79,055 | 17.9 | 134.9 |
| Connecticut | ...... | ...... | ...... | ...... | ...... | ...... | 439,733 | 20.1 | 167.1 |
| **Middle Atlantic:** | | | | | | | | | |
| New York | ...... | ...... | ...... | ...... | ...... | ...... | 2,677,594 | 12.8 | 208.8 |
| New Jersey | ...... | ...... | ...... | ...... | ...... | ...... | 231,865 | 9.0 | 84.9 |
| Pennsylvania | 9,515 | 5.5 | 139.9 | ...... | ...... | ...... | 1,627,399 | 8.7 | 191.6 |
| **North Central:** | | | | | | | | | |
| Ohio | ...... | ...... | ...... | ...... | ...... | ...... | 1.592,363 | 6.6 | 242.0 |
| Indiana | ...... | ...... | ...... | ...... | ...... | ...... | 997,780 | 4.7 | 80.8 |
| Illinois | ...... | ...... | ...... | ...... | ...... | ...... | 1,326,735 | 4.1 | 113.0 |
| Iowa | ...... | ...... | ...... | ...... | ...... | ...... | 2,125,374 | 6.3 | − .3 |
| Missouri | 13,324 | 1.7 | 150.4 | ...... | ...... | ...... | 1,090,249 | 3.1 | 9.4 |
| **Lake:** | | | | | | | | | |
| Michigan | 3,641 | 12.3 | ...... | ...... | ...... | ...... | 3,180,982 | 16.8 | 200.6 |
| Wisconsin | ...... | ...... | ...... | ...... | ...... | ...... | 3,774,880 | 18.0 | 165.4 |
| Minnesota | 113,284 | 18.8 | 39,234.7 | 6,575 | 6.8 | 16,759.9 | 4,109,899 | 14.8 | − .4 |
| **South Atlantic:** | | | | | | | | | |
| Delaware | ...... | ...... | ...... | ...... | ...... | ...... | 73,296 | 7.0 | 14.2 |
| Maryland | ...... | ...... | ...... | ...... | ...... | ...... | 234,673 | 4.7 | 64.0 |
| Virginia | 29,102 | 3.0 | − 81.4 | ...... | ...... | ...... | 1,209,678 | 6.2 | − 45.0 |
| West Virginia | 8,702 | 1.6 | − 15.4 | 2,454 | 1.9 | 87.3 | 535,849 | 5.3 | 142.4 |
| North Carolina | 253,257 | 3.6 | − 34.2 | 8,724 | 3.2 | 194.9 | 1,174,334 | 5.2 | − 41.7 |
| South Carolina | 92,624 | 3.5 | − 41.4 | 17,588 | 7.8 | 51.5 | 1,074,887 | 8.0 | − 48.1 |
| Georgia | 146,569 | 2.6 | 50.8 | 45,113 | 2.4 | 114.9 | 1,652,655 | 6.2 | − 35.7 |
| Florida (26 northern counties) | 60,045 | 5.5 | 212.4 | 7,196 | 3.8 | 14.9 | 171,797 | 4.8 | 33.2 |
| **South Central:** | | | | | | | | | |
| Kentucky | 43,037 | 1.9 | 28.1 | ...... | ...... | ...... | 883,080 | 4.0 | 34.3 |
| Tennessee | 56,987 | 3.9 | 125.2 | ...... | ...... | ...... | 1,143,440 | 5.7 | 22.0 |
| Arkansas | 118,248 | 3.6 | 31.0 | ...... | ...... | ...... | 828,311 | 4.7 | 37.0 |
| Alabama | 145,907 | 6.5 | 94.9 | 7,020 | 2.0 | 28.8 | 1,593,967 | 7.6 | − 22.2 |
| Mississippi | 81,310 | 6.1 | 107.7 | 12,368 | 5.1 | − 45.3 | 1,665,665 | 9.0 | 11.5 |
| Louisiana | 51,238 | 4.5 | 24.3 | ...... | ...... | ...... | 846,904 | 8.2 | − 13.2 |

Under proper farm management land not suitable for cultivation or pasturage ought to be kept in timber and made to contribute to the farm income. While it is unavoidable that financial stringency or exceptionally high prices will sometimes occasion the sale of woodlots which might otherwise be directly or indirectly a source of permanent income to the farm, it is too often the case that the owners are easily tempted by such offers and do not stop to weigh them against the greater advantage that can perhaps be secured in the long run by leaving the woodlot standing.

Statistics showing the actual number of farms which have woodlots are not available. In the thickly settled regions there are many small farms, and some of fair size, which have no woodlots, but this becomes less and less the case with remoteness from the more densely populated centers. At the same time, the average size of the woodlots, obtained by dividing the total woodlot area by the total number of farms, increases from the least to the most wooded farm regions. This is shown in Table 6, which gives the average woodlot acreage per farm in different States and divisions for 1880 and 1910. The average proportion of farm land wooded is shown for the same years in Table 7.

TABLE 6.—*Average size of woodlots, 1910 and 1880 (assuming a woodlot on each farm).*

| State or State group. | Woodland per farm | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Division I. | | Division II. | | Division III. | | Division IV. | | Division V. | | Division VI. | | Total. | |
| | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 |
| | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* | *Acres.* |
| Eastern United States | 7.4 | 13.1 | 13.7 | 25.1 | 27.0 | 49.2 | 44.6 | 80.6 | 72.9 | 150.3 | 161.6 | 273.3 | 29.2 | 66.8 |
| New England | [1] 11.1 | 1.1 | 11.1 | 12.0 | 34.1 | 28.0 | 49.2 | 42.6 | | | | | 41.6 | 35.3 |
| Middle Atlantic | 5.5 | 8.2 | 13.7 | 16.6 | 27.0 | 33.0 | 46.7 | 55.7 | 157.9 | 118.4 | | | 19.8 | 24.0 |
| North Central | 7.8 | 13.1 | 14.1 | 27.4 | 31.0 | 46.8 | 64.3 | 90.7 | 91.1 | 85.9 | | | 17.0 | 27.1 |
| Lake States | 8.2 | 13.8 | 13.6 | 25.4 | 37.4 | 49.9 | 52.7 | 70.2 | 82.4 | 71.3 | 141.3 | 136.5 | 22.6 | 29.6 |
| South Atlantic | 7.4 | 19.0 | 16.7 | 28.2 | 27.2 | 62.4 | 44.4 | 83.9 | 74.9 | 159.1 | 166.7 | 287.3 | 43.8 | 86.5 |
| South Central | 4.8 | 18.6 | 10.3 | 37.7 | 21.6 | 58.4 | 41.1 | 91.6 | 68.1 | 139.9 | 144.9 | 180.6 | 32.7 | 74.9 |
| New England: | | | | | | | | | | | | | | |
| Maine | | | | | 33.2 | 25.7 | 49.8 | 46.2 | | | | | 46.2 | 41.7 |
| New Hampshire | | | | | | | 55.5 | 40.3 | | | | | 55.5 | 40.3 |
| Vermont | | | 15.8 | 16.3 | 15.9 | 38.7 | 65.6 | 72.9 | | | | | 47.9 | 42.3 |
| Massachusetts | [1] 11.1 | 1.1 | 18.7 | 19.5 | 28.7 | 24.7 | 29.4 | 30.6 | | | | | 28.8 | 26.1 |
| Rhode Island | | | 6.8 | 7.1 | 8.4 | 7.2 | 43.7 | 35.0 | | | | | 35.1 | 29.4 |
| Connecticut | | | | | 26.7 | 20.3 | 37.1 | 25.8 | | | | | 28.3 | 21.1 |
| Middle Atlantic: | | | | | | | | | | | | | | |
| New York | 5.1 | 7.4 | 15.3 | 16.3 | 26.5 | 27.1 | 48.9 | 50.1 | | | | | 20.6 | 21.6 |
| New Jersey | | .7 | 11.0 | 13.0 | 23.0 | 25.6 | 23.0 | 61.2 | | | | | 16.2 | 20.6 |
| Pennsylvania | 5.7 | 8.9 | 12.5 | 17.6 | 28.1 | 41.4 | 50.2 | 63.4 | 157.9 | 118.4 | | | 19.5 | 27.2 |
| North Central: | | | | | | | | | | | | | | |
| Ohio | 6.9 | 17.2 | 12.1 | 24.4 | 25.0 | 42.9 | 40.5 | 55.3 | | | | | 12.1 | 24.2 |
| Indiana | 9.0 | 23.7 | 12.8 | 28.3 | 27.6 | 41.3 | 46.5 | 64.3 | | | | | 15.6 | 30.6 |
| Illinois | 8.1 | 11.6 | 15.9 | 28.8 | 29.6 | 39.9 | 54.2 | 75.0 | | | | | 12.5 | 19.3 |
| Iowa | 7.2 | 9.5 | 17.8 | 23.9 | 34.5 | 40.3 | | | | | | | 10.7 | 14.9 |
| Missouri | 9.7 | 20.5 | 16.1 | 32.3 | 34.5 | 55.8 | 66.2 | 94.4 | 94.1 | 85.9 | | | 32.2 | 47.0 |
| Lake States: | | | | | | | | | | | | | | |
| Michigan | 8.8 | 21.7 | 11.4 | 26.2 | 27.1 | 65.7 | 43.8 | 105.5 | 72.9 | | | | 14.1 | 28.9 |
| Wisconsin | 9.0 | 15.4 | 14.8 | 23.9 | 40.1 | 50.1 | 51.8 | 71.6 | | | | | 30.4 | 35.5 |
| Minnesota | 7.7 | 9.4 | 22.5 | 24.2 | 39.2 | 41.8 | 60.0 | 54.9 | 82.9 | 71.3 | 141.3 | 136.5 | 25.1 | 22.0 |
| South Atlantic: | | | | | | | | | | | | | | |
| Delaware | | | 12.6 | 12.8 | 26.0 | 37.8 | | | | | | | 28.3 | 31.9 |
| Maryland | | | 16.8 | 22.7 | 27.4 | 37.1 | 49.9 | 73.5 | | | | | 30.0 | 40.3 |
| Virginia | | | 26.6 | 36.4 | 36.4 | 74.7 | 49.3 | 74.8 | 81.9 | 153.6 | | | 45.7 | 77.0 |
| West Virginia | 7.4 | 19.0 | 15.1 | 35.6 | 29.7 | 72.1 | 56.1 | 153.7 | 64.9 | 158.6 | 123.7 | 173.0 | 41.0 | 98.6 |
| North Carolina | | | | | 27.9 | 61.0 | 42.1 | 72.2 | 69.2 | 125.3 | 136.1 | 286.9 | 49.1 | 88.0 |
| South Carolina | | | | | 22.5 | 51.9 | 35.5 | 77.5 | 61.2 | 138.7 | 179.3 | 347.3 | 35.9 | 77.8 |
| Georgia | | | | | 24.6 | 66.7 | 43.8 | 97.6 | 89.8 | 278.9 | 181.3 | 314.3 | 44.7 | 110.1 |
| Florida (26 northern counties) | | | | | 25.0 | 49.3 | 50.9 | 90.0 | 82.5 | 101.3 | 126.7 | 163.5 | 61.1 | 92.2 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South Central: | | | | | | | | | | | | | | |
| Kentucky | 5.0 | 19.0 | 12.1 | 35.7 | 25.3 | 56.4 | 39.7 | 92.2 | 68.3 | 202.1 | | | 26.8 | 60.7 |
| Tennessee | | | 11.1 | 42.9 | 22.0 | 47.2 | 44.1 | 89.4 | 78.1 | 158.4 | | | 32.6 | 67.8 |
| Arkansas | | | 6.9 | 62.9 | 20.6 | 74.0 | 39.3 | 84.0 | 70.9 | 90.9 | | | 39.6 | 83.2 |
| Alabama | | | 9.5 | 25.7 | 22.9 | 57.6 | 41.5 | 89.4 | 63.8 | 140.5 | 175.8 | 141.2 | 35.9 | 76.8 |
| Mississippi | | | 7.8 | 97.7 | 16.4 | 71.2 | 40.9 | 96.6 | 64.1 | 136.3 | 115.0 | 190.6 | 28.7 | 89.9 |
| Louisiana | 3.5 | 12.4 | 10.1 | 31.5 | 28.3 | 80.2 | 41.8 | 112.8 | 62.9 | 121.0 | | | 35.8 | 94.4 |

[1] Nantucket Island only.

TABLE 7.—*Average proportion of farm land wooded, 1910 and 1880.*

| State or State group. | Division I. | | Division II. | | Division III. | | Division IV. | | Division V. | | Division VI. | | Total. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 |
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Eastern United States | 5.6 | 11.1 | 14.0 | 24.3 | 30.0 | 39.7 | 48.4 | 57.1 | 66.9 | 77.8 | 84.3 | 88.6 | 29.4 | 38.5 |
| New England | 8.6 | .5 | 16.5 | 15.7 | 33.5 | 27.9 | 45.8 | 39.7 | | | | | 39.8 | 34.1 |
| Middle Atlantic | 8.4 | 11.8 | 15.4 | 18.5 | 26.9 | 31.1 | 43.1 | 46.9 | 79.3 | 73.5 | | | 21.6 | 25.2 |
| North Central | 5.6 | 10.4 | 13.5 | 25.1 | 27.0 | 38.1 | 49.6 | 63.9 | 66.2 | 73.0 | | | 14.4 | 23.0 |
| Lake States | 4.9 | 10.8 | 13.3 | 26.2 | 29.0 | 39.5 | 44.0 | 56.6 | 66.8 | 71.5 | 85.9 | 82.2 | 18.1 | 26.4 |
| South Atlantic | 8.8 | 15.7 | 15.8 | 23.0 | 32.4 | 42.5 | 48.7 | 55.3 | 67.5 | 77.9 | 84.4 | 80.9 | 46.9 | 54.9 |
| South Central | 5.9 | 17.3 | 16.3 | 32.8 | 30.4 | 46.2 | 49.9 | 63.2 | 65.8 | 77.9 | 83.8 | 76.9 | 41.2 | 54.9 |
| New England: | | | | | | | | | | | | | | |
| Maine | | | | | 35.0 | 29.5 | 46.3 | 43.6 | | | | | 44.1 | 40.9 |
| New Hampshire | | | | | | | 46.2 | 37.8 | | | | | 46.2 | 34.8 |
| Vermont | | | 17.3 | 16.4 | 32.2 | 28.9 | 43.8 | 43.1 | | | | | 33.6 | 30.8 |
| Massachusetts | 8.6 | .5 | 14.4 | 19.7 | 35.3 | 27.7 | 43.1 | 37.7 | | | | | 37.0 | 29.9 |
| Rhode Island | | | 14.5 | 12.4 | 20.7 | 16.0 | 45.8 | 39.0 | | | | | 41.9 | 35.5 |
| Connecticut | | | | | 33.1 | 25.5 | 43.3 | 31.1 | | | | | 34.7 | 26.4 |
| Middle Atlantic: | | | | | | | | | | | | | | |
| New York | 7.3 | 10.5 | 15.1 | 16.8 | 24.6 | 25.7 | 43.7 | 43.8 | | | | | 20.3 | 21.8 |
| New Jersey | | 3.6 | 14.5 | 15.7 | 27.3 | 28.9 | 41.8 | 62.6 | | | | | 20.9 | 24.2 |
| Pennsylvania | 9.2 | 12.8 | 16.0 | 21.3 | 29.4 | 37.9 | 42.7 | 48.2 | 79.3 | 73.5 | | | 23.1 | 29.4 |
| North Central: | | | | | | | | | | | | | | |
| Ohio | 8.2 | 18.1 | 13.6 | 24.8 | 25.2 | 34.8 | 42.5 | 44.2 | | | | | 13.6 | 24.4 |
| Indiana | 8.3 | 22.2 | 13.4 | 28.1 | 26.7 | 34.8 | 42.6 | 54.6 | | | | | 15.8 | 29.1 |
| Illinois | 5.8 | 9.0 | 13.6 | 24.5 | 25.9 | 38.0 | 40.0 | 57.7 | | | | | 9.7 | 15.6 |
| Iowa | 4.5 | 7.0 | 12.8 | 18.4 | 22.6 | 30.7 | | | | | | | 6.8 | 11.1 |
| Missouri | 7.0 | 16.2 | 13.6 | 25.9 | 28.7 | 43.2 | 50.2 | 65.4 | 66.2 | 73.0 | | | 25.8 | 36.4 |
| Lake States: | | | | | | | | | | | | | | |
| Michigan | 4.6 | 22.8 | 12.8 | 30.1 | 27.6 | 63.4 | 43.2 | 81.1 | 68.6 | | | | 15.5 | 32.2 |
| Wisconsin | 8.0 | 13.9 | 14.3 | 23.7 | 30.6 | 39.3 | 44.1 | 58.9 | | | | | 25.5 | 31.1 |
| Minnesota | 3.7 | 6.2 | 13.6 | 16.8 | 27.0 | 30.7 | 43.8 | 42.8 | 66.7 | 71.5 | 85.9 | 82.2 | 14.2 | 15.2 |

TABLE 7.—*Average proportion of farm land wooded, 1910 and 1880*—Continued.

| State or State group. | Division I. |  | Division II. |  | Division III. |  | Division IV. |  | Division V. |  | Division VI. |  | Total. |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 | 1910 | 1880 |
| South Atlantic: | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Delaware | ... | ... | 11.9 | 10.4 | 27.9 | 30.2 | ... | ... | ... | ... | ... | ... | 24.3 | 25.6 |
| Maryland | ... | ... | 16.2 | 19.4 | 27.8 | 30.9 | 44.1 | 47.2 | ... | ... | ... | ... | 29.0 | 31.9 |
| Virginia | ... | ... | 17.4 | 20.7 | 33.3 | 44.1 | 48.7 | 46.5 | 64.1 | 63.1 | ... | ... | 43.2 | 46.0 |
| West Virginia | 8.8 | 15.7 | 15.6 | 30.6 | 30.6 | 53.8 | 49.1 | 70.7 | 69.5 | 84.9 | 84.5 | 89.1 | 39.6 | 60.6 |
| North Carolina | ... | ... | ... | ... | 36.5 | 48.9 | 50.7 | 55.3 | 67.4 | 74.7 | 84.6 | 93.2 | 55.5 | 62.0 |
| South Carolina | ... | ... | ... | ... | 34.0 | 39.2 | 46.6 | 56.1 | 66.1 | 75.5 | 81.9 | 85.9 | 46.9 | 53.9 |
| Georgia | ... | ... | ... | ... | 32.6 | 42.1 | 47.9 | 57.9 | 68.3 | 85.9 | 84.6 | 90.0 | 48.2 | 58.6 |
| Florida (26 northern counties) | ... | ... | ... | ... | 32.2 | 37.4 | 47.8 | 61.2 | 70.0 | 73.9 | 85.2 | 88.4 | 55.8 | 63.4 |
| South Central: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Kentucky | 6.1 | 17.8 | 16.2 | 31.5 | 28.4 | 45.9 | 47.1 | 63.2 | 68.3 | 85.9 | ... | ... | 31.3 | 47.0 |
| Tennessee | ... | ... | 15.7 | 51.1 | 30.0 | 43.7 | 48.8 | 62.9 | 66.5 | 78.9 | ... | ... | 40.0 | 54.4 |
| Arkansas | ... | ... | 18.3 | 53.6 | 33.0 | 61.5 | 48.2 | 65.3 | 64.6 | 68.7 | ... | ... | 48.9 | 65.2 |
| Alabama | ... | ... | 17.0 | 27.1 | 32.5 | 42.5 | 50.6 | 63.0 | 63.4 | 77.5 | 85.5 | 78.1 | 45.6 | 55.3 |
| Mississippi | ... | ... | 18.2 | 46.6 | 30.4 | 49.2 | 49.2 | 63.0 | 66.8 | 75.8 | 81.4 | 76.6 | 42.5 | 57.7 |
| Louisiana | 4.5 | 10.2 | 12.8 | 23.9 | 30.9 | 48.0 | 49.8 | 60.6 | 66.4 | 76.5 | ... | ... | 41.3 | 55.1 |

### INCREASE IN VALUE OF WOODLOT PRODUCTS.

The value of woodlot products cut each year in the Eastern States has increased rapidly. Between 1880 and 1910 the increase was over 90 per cent. It was due partly to the rapid rate of clearing and partly to the increase in the intrinsic value of the products. The rate of increase varies with the region. In thinly settled regions it is rapid; in thickly settled regions, slow. This is shown for the Eastern States as a whole and in geographic groups in Table 8, which also gives the total amount of income from woodlot products in 1909 according to the Thirteenth Census, the percentage of farms which reported woodlot incomes, and the proportion of income represented by wood sold and wood used on the farm. As a rule, less than half the total number of farms reported woodlot products. This does not mean that less than half had woodlots, since there were undoubtedly many farms with woodlots which cut no timber in that year.

**Table 8.**—*Total value of woodlot products, 1909, with increase in value since 1899 and 1879.*

[Compiled from Thirteenth Census, Vol. V, Table 154.]

| State groups. | Proportion of farms reporting woodlot products. | Value of woodlot products. | | | Increase in value since— | |
|---|---|---|---|---|---|---|
| | | Total. | Proportion used on farms. | Proportion sold. | 1899 (10 years). | 1879 (30 years). |
| | *Per cent.* | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Eastern United States | 43.2 | $169,948,468 | 52.7 | 47.3 | 70.5 | 90.9 |
| New England | 61.5 | 17,664,763 | 35.4 | 64.6 | 68.7 | 78.8 |
| Middle Atlantic | 43.2 | 19,110,765 | 48.0 | 52.0 | 30.7 | 21.7 |
| North Central | 31.8 | 26,746,377 | 61.8 | 38.2 | 26.6 | 11.9 |
| Lake States | 50.8 | 22,652,837 | 57.6 | 42.4 | 39.4 | 95.8 |
| South Atlantic | 50.3 | 44,010,178 | 51.0 | 49.0 | 137.3 | 213.1 |
| South Central | 42.0 | 39,763,548 | 55.5 | 44.5 | 113.4 | 185.6 |

The last two columns of Table 8 show that the greater part of the increase in the 30 years from 1879 to 1909 came in the last 10 years. This is especially striking in the case of the Middle Atlantic and North Central States, where the value of woodlot products was actually greater in 1879 than in 1899. This is perhaps attributable chiefly to the greater aggregate quantity of timber cut in these States in the former year, when clearing was active. The great rise in the last 10 years was due primarily to the general rise in value of wood products. though partly also to the large quantities of wood available from clearing.

### AMOUNT AND QUALITY OF WOODLOT TIMBER.

Though the area in woodlots is quite closely known, the total stand of woodlot timber can only be estimated. Such an estimate was made in 1909.[1] In the States considered in this bulletin, about 40 per cent of the total woodlot area, or 58,000,000 acres, were estimated to contain merchantable timber suitable for lumber, veneer, etc.; about 45 per cent, or 65,200,000 acres, had cordwood; and about 15 per cent, or 21,800,000 acres, were brush land of only potential value. Assuming that the average stand of merchantable timber is 3,000 board feet per acre, with 10 standard cords of wood in addition, and that the average stand in the woodlots fit for cordwood only is 8 cords per acre, the total stand would be 174,000,000,000 board feet of log timber and about 1,100,000,000 cords of other wood. According to this estimate, the stand of log timber alone equals 15.6 per cent, or nearly one-sixth of all standing timber in the Eastern States.[2]

A large proportion of the woodlots have been culled of their best timber, and many have been so badly depleted by overcutting, grazing, and fire that there is very little material left in them of more than firewood value. Ignoring the fact that many of the large commercial forests have suffered in the same way, it is often argued that woodlot timber is essentially inferior to that of the timber forests and that it is suited for only a few kinds of rough products—rough lumber for farm buildings, cordwood for fuel, posts for the farm fences, a few ties and poles for sale to railroad, telegraph, and telephone companies, etc. This argument may be justified, so far as lumber is concerned, by the fact that farm lumber when cut and sold by the owner or a local sawyer is apt to be poorly manufactured, poorly graded, and poorly seasoned; but it is not true that the producing value of woodlots is restricted to the rough products above mentioned. A very large part of the high-grade hickory, ash, and white oak, now becoming scarce because of their extensive use in the vehicle, handle, cooperage, and other industries, comes from woodlots. Many woodlots contain timber every bit as good as that in the larger tracts and fully as capable of yielding high-grade lumber if properly sawed and seasoned. Throughout the Eastern States woodlots contain large quantities of pulpwood suitable for paper making, low-grade lumber for boxes, bolts for slack and tight barrel cooperage, and excellent log and bolt material of many species for veneer. There is hardly a use to which wood is put that can not be contributed to, liberally, from the woodlot supply. That fuel is a proportionately large part of the woodlot output does not imply that woodlots run more largely to low-grade material than the larger

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[1] "Standing Timber in Woodlots," by Wesley Bradfield, in Report of the National Conservation Commission, 1909, Vol. II, pp. 181–187.

[2] The total stand in the States covered by this bulletin is estimated as 1,117,700,000,000 board feet by H. S. Betts and W. B. Greeley ("Structural Timber in the United States," Sept., 1915). This estimate is based largely on reports of the Bureau of Corporations and of the National Conservation Commission.

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forests. On the contrary, it may signify a closer utilization of branches and small or inferior trees.

## WHAT THE WOODLOT PROMISES FOR THE FUTURE.

Since anything which benefits the farms contributes to the general prosperity, the woodlots must be considered a national asset from both the direct and the indirect standpoints. It is of manifest advantage to have maintained throughout the country small bodies of timber not only to supply the local demands for wood, which will increase as the existing large bodies of timber decrease in amount, but also as a possible factor in preserving good climatic conditions, in checking the sweep of winds, preventing the undue washing of soil, and in contributing an object of variety and beauty to a land surface a large part of which would otherwise be bare and monotonous. As a supply of wood products for local consumption woodlots have lessened the drain on the general markets fed by the large-scale lumbering operations and have contributed much of the raw material used for veneer, vehicle, cooperage, and handle making, paper, pulp, and excelsior manufacture, wood for fuel, and other important uses.

The future of the woodlot can be predicted with some degree of assurance. It hinges principally upon the attitude which the farmers will take. Except in New England and a few smaller regions in which raising timber in woodlots is already an important source of farm income, most farmers are still prone to regard their woods as a transitory asset to be realized once only when the land is finally cleared. As agricultural development proceeds, the decrease in the aggregate area of farm woodland is bound to continue; but a reduction in the rate of decrease can be expected as the farmers come to realize more fully the advantages of owning thrifty woodlands. The inaccurate and misleading conception of the woodlot as only a temporary asset will yield to an increasing appreciation of it as a growing crop, like any other farm crop. Eventually, a relatively stable condition of woodlot area will probably be reached, which may vary locally according to local demand and supply, but for the country as a whole will tend to remain fairly constant. Farms in hilly or mountainous regions, having larger proportions of untillable lands, will also have larger woodlots than those in level country; but even the latter may be expected, considering their nearness to manufacturing centers, to have moderate amounts of woodland of high producing value.

With proper treatment, it is not unlikely that the woodlots now existing could be made to yield perpetually an average of half a standard cord[1] of wood per acre per year. At this rate an aggregate annual yield of 71,500,000 cords could be expected in perpetuity from the present total woodlot area of 143,000,000 acres. To equal the total income from farm wood as reported by the census of 1910, the value per cord would have to be only $2.38.

If it is assumed that the permanent woodlot area of the future will amount to an average of 10 acres per farm[2] or a total for the Eastern States of 49,030,850 acres (based on the number of farms in 1910), the sustained annual yield supported by a growth of one-half cord per acre per year would aggregate 24,515,425 cords. In order to equal the income from woodlots in 1910 the value per cord would have to be $6.93, nearly three times as great as that previously assumed; but it is not improbable that future stumpage values will rise to this or even to higher levels.

As the population increases farming tends to become more intensive and the application of scientific principles to farming more essential. These principles involve, above all, the careful study of the productivity of the various kinds of soil on the farm and the choice for each kind of soil of the kind of crop best adapted to it. This means that wood, considered as a farm crop, will be raised only on soils which can not be made to yield a greater revenue from some other crop. In the pioneering stage of agriculture wood has had, and in many sections still has, a very low value compared with other crops which might be raised on much of the same land. In the more thickly settled regions, however, its relative value has increased in the past, and as the population becomes dense and the present large timber supplies fail this value may be expected to increase still more in relation to other crops. In other words, the quality of soil on which it will be profitable to keep woodlots for productive purposes alone may, in the light of future intensification of agriculture, be higher than one would be likely, at first glance, to suppose. This presupposes, of course, as high scientific thought and attention to the woodlot in the selection of species, stimulation of growth, and other silvicultural treatment as would be given any of the other farm crops by a farmer bent on getting the most out of every square rod of his land.

As an immediate measure too much emphasis can not be placed on the importance to farm and community alike of retarding to a reasonable extent the process of shrinkage in farm woodlands. Overmature and decaying woods, it is true, must often be cut at once to secure any return from them, and financial stringency may force the sacrifice of young, thrifty stands without suitable provision for securing a new growth at least equally good. Clearing under these conditions is inevitable. But there is a pronounced tendency, especially upon transfers of title to farm property, to clear land recklessly for whatever small value is offered. This is shown by the great increase in unimproved lands without woods, which, according to Table 5, amounted to 34 per cent in the 30 years between 1880 and 1910. By cooperation in control of farm property this situation might in large measure be rectified.

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[1] A standard cord is a pile of wood in 4-foot lengths, measuring 8 by 4 by 4 feet, and containing 128 cubic feet. The cord unit is used here to represent growth not only in fuel wood, but also in logs, poles, and other high-grade forms customarily measured in board feet or other units. This should be borne in mind with reference to the prices per cord which follow; these would of course be excessive for ordinary cordwood. In medium-sized or small timber 1,000 board feet, Scribner, are usually considered equivalent to from 2 to 5 cords of cordwood.

[2] The present average is 29.2 acres. (See Table 6.)

### WOODLOTS AND COMMUNITY FORESTS.

The highest direct value of woodlots is to the local communities. Census statistics for 1909 show that the farms themselves consumed over half the value of the woodlot products. Of the material sold much undoubtedly went to near-by farms, or to local dealers in lumber and fuel, to be retailed for consumption in the neighborhood. A great many small veneer, vehicle, cooperage, and other factories derive their entire supply from local woodlots.

There is thus every incentive for communities to encourage the development of local woodlots and thereby protect themselves from future timber scarcity and high prices. Several States have already taken steps in this direction by passing laws providing for a final yield tax on timber when cut instead of the annual taxation still customary in many States. Such legislation, together with the gradually increasing value of timber, appeals to the individual farmers and will doubtless encourage many of them to practice woodlot forestry. But in order to insure a perpetual annual yield of timber in desirable forms and in substantially equal quantities other steps are necessary. Timber is a "long-time" crop. To secure annual yields of any size a comparatively large aggregate area, managed under a single working plan, is essential, though the timber may be divided among many small, isolated tracts. The individual farmer can not, therefore, practice forestry as a business except in a small way. It is possible that individuals may occasionally be induced to pool their woodlot properties under a single system of operation. This may work out in connection with the development of the present cooperative movement among farmers. It is probable, however, that in the future a separate class of forest holdings, community or town forests, intermediate in character between the farm woodlot and the larger, more remote bodies of timber, will afford permanent annual supplies of wood products to local communities.

Europe affords many illustrations of successful communal forests.[1] In France, for example, over 11,000 communities have forests, with an aggregate area of 5,000,000 acres—nearly a quarter of the total forest area of the country. In Austria over 3,000,000 acres, in Germany 5,600,000 acres, and in Switzerland nearly 1,350,000 acres belong to communities. Italian communal forests form over 43 per cent of the total forest area. The amount of woodland owned by a single community varies from 2½ to over 15,000 acres. In Prussia the size averages about 2,000 acres, but this is probably the highest for all Germany.

The income from European communal forests is very large considering the poor quality of soil on which the timber thrives. The better managed of them yield annually a net income of from $7 to over $10 per acre. The average gross revenue from 2,000 acres would be about $6,500, and it is not surprising to find communities that derive from these forests a revenue sufficient not only to pay all the taxes corresponding to our county, town, and school taxes, but to yield, in addition, an annual dividend to every householder. From the 2,500 acres of timber owned by the Swiss city of Zurich, for example, the net income has averaged as much as $20,000 per year for a period of 10 years; and Freiberg, in Germany, derives from $20,000 to $30,000 annually from its 3,000-acre woodlot. It is estimated that the 5,600,000 acres of communal forest in Germany yield annually a net income of $9,250,000, which, capitalized at even 3 per cent, represents a property worth $308,000,000.

Though the returns mentioned above are undoubtedly far in excess of any which could be obtained in this country for years to come, they at least indicate a great possibility for the future development of the American woodlot. There are always soils available which are too poor, swampy, or steep for cultivation, orchard, or even pasture, and it is on these that tree growth can be practiced with success. Already there are more than 60 American cities and towns, situated in 10 or 15 States, which have acquired municipal forests ranging in area from 50 to 25,000 acres.[2] While the primary object of these holdings is ordinarily to protect water supplies from contamination, many of them are already being carefully managed, and it is only a question of time when many will yield a direct income over and above their value for protection.

### WOODLOTS AND PUBLIC FORESTS.

The largest share of the timber for consumption in the future must unquestionably be grown on areas set aside as National and State forests, or areas managed by stable and long-lived corporations. Such forests can be located only in nonagricultural regions, or at least in regions in which soil for practicable cultivation is confined to small and widely separated areas. Usually these forests will combine the functions of timber raising with those of watershed protection, recreation, and other purposes. Incidentally, they may serve, like the woodlots, as means of ameliorating the climate of regions lying to the leeward.

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[1] The figures which follow are taken from "Communal Forests," by Raphael Zon, in Bailey's "Cyclopedia of American Agriculture," Vol. IV, pp. 144–148; 1909.

[2] See "County, City, Town, and School Forests," by Prof. J. W. Toumey, in American Forestry, July, 1916, pp. 428–429.

In farming regions adjacent to public forest areas, the large supply of available timber will make farm woodlots of relatively minor importance compared with those farther from the large forests and closer to manufacturing centers. In such situations, the woodlot will more than ever be relegated to the poor farm lands which can not be used to advantage for other purposes; but as compared with existing woodlots in mountainous regions, the value under future conditions of demand and supply will probably be a sufficient incentive to the care and practical management of even the mountain woodlot as a valuable farm crop.

The solution of the problem of timber production in the East will undoubtedly be a combination of all the classes of ownership above outlined. Each one has its distinct place, and the private or communal woodlots as a source of many kinds of timber for many uses will serve to fill varied local demands and thereby reduce the drain on the larger bodies of forest.

## THE WOODLOT AS A FARM RESOURCE.

The value of woodlots to farms includes not only the direct income value from the wood products which are or might be produced, but also a variety of indirect benefits, such as the protection of stock, crops, and buildings from sun and wind, prevention of soil erosion, renewal of worn-out soils, improvement to the appearance of the farm, etc. Thus a woodlot may at the same time increase the general prosperity of the farm, add to its comfort as a home, and enhance its value as an investment. In some parts of the country the indirect uses, though not measurable in dollars and cents, are even more valuable than the direct wood-producing function of the woodlot; but, since they are more or less intangible, farmers are likely to neglect them in deciding whether to preserve or clear away their woodlots.

The farmer has a permanent interest in his property, and it is to his advantage to increase its value both as a present home and as an inheritance for his children. In both respects a farm with a well-tended and well-proportioned woodlot is worth more than one without, over and above the stumpage value of the trees themselves. It has been estimated that in parts of Minnesota woodlots as small as 5 acres will increase farm values by $500, and this is probably a conservative estimate for the country as a whole.

As a producing crop the woodlot is valuable mainly as a "poor-land crop," yielding a higher income than other crops from soil too steep, stony, swampy, or "worn out" for successful cultivation. In pioneering regions much good, tillable soil besides must often remain for years uncultivated, owing to lack of means to improve it. It is a mistake to clear such land in advance of the farmer's ability to put it into crops, unless very good prices are offered for the timber. Even when profitable sales are made, part of the woodlot can be left and improved by the taking out of only a designated portion of the trees. When high prices for wood become general, little additional incentive will be needed to preserve and improve the woodlots.

In thinly settled regions and in some of the States as a whole woodlot products yield a very considerable part of the total farm income. In New Hampshire and Vermont, for example, woodlot products are the second most important farm crop; in Maine, South Carolina, Georgia, Alabama, Mississippi, and Arkansas, they are the third. Where farming is in a pioneering stage, the sale of wood is very often the determining factor which enables the farmer to tide over the first years during which he has not enough land in cultivation to support him. How the woodlot income compared in 1909 with the total farm income in different regions in each State is shown in Table 9. The relative importance of woodlot products as a source of income is well brought out in the case of Minnesota, for example, where it was progressively greater from Division I, with 1 per cent of the total farm income, to Division VI, where it formed nearly 45 per cent.

TABLE 9.—*Woodlot income in per cent of total income, 1910.*

[Based on averages of census returns from 450 counties chosen at random from the woodlot divisions in each State.]

| State or State group. | Proportion of total farm income, 1910. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Division I. | Division II. | Division III. | Division IV. | Division V. | Division VI. | Total. |
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Eastern United States | 1.3 | 3.2 | 5.6 | 9.1 | 11.0 | 19.1 | 5.2 |
| New England | | 1.5 | 10.8 | 14.4 | | | 12.5 |
| Middle Atlantic | 1.6 | 3.6 | 7.4 | 12.4 | 20.5 | | 4.6 |
| North Central | 1.0 | 2.8 | 5.0 | 6.5 | 7.3 | | 2.5 |
| Lake States | 1.7 | 3.7 | 6.6 | 17.2 | 35.0 | 44.8 | 5.2 |
| South Atlantic | | 3.9 | 4.6 | 7.3 | 9.3 | 18.4 | 6.4 |
| South Central | 1.8 | 2.3 | 3.9 | 6.7 | 11.7 | | 5.3 |
| New England: | | | | | | | |
| Maine | | | 13.6 | 13.0 | | | 13.1 |
| New Hampshire | | | | 22.1 | | | 22.1 |
| Vermont | | | 11.6 | 16.1 | | | 12.9 |
| Massachusetts | | | 10.7 | 8.3 | | | 10.1 |
| Rhode Island | | 1.5 | 1.7 | 13.9 | | | 7.8 |
| Connecticut | | | 8.9 | 13.5 | | | 9.7 |

TABLE 9.—*Woodlot income in per cent of total income, 1910*—Continued.

| State or State group. | Proportion of total farm income, 1910. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Division I. | Division II. | Division III. | Division IV. | Division V. | Division VI. | Total. |
| Middle Atlantic: | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| New York | 1.1 | 4.1 | 8.8 | 15.2 | .......... | .......... | 5.4 |
| New Jersey | .......... | 2.0 | 1.8 | 2.6 | .......... | .......... | 1.9 |
| Pennsylvania | 1.8 | 3.4 | 7.3 | 13.5 | 20.5 | .......... | 4.3 |
| North Central; | | | | | | | |
| Ohio | 1.6 | 3.5 | 5.2 | 3.5 | .......... | .......... | 3.1 |
| Indiana | 1.0 | 3.5 | 5.5 | 6.7 | .......... | .......... | 3.1 |
| Illinois | .7 | 1.8 | 2.9 | .......... | .......... | .......... | 1.2 |
| Iowa | 1.0 | 2.4 | 4.5 | .......... | .......... | .......... | 2.0 |
| Missouri | 1.0 | 3.3 | 6.2 | 11.6 | 7.3 | .......... | 3.7 |
| Lake States: | | | | | | | |
| Michigan | 4.1 | 4.7 | 11.2 | 20.2 | 28.4 | .......... | 6.4 |
| Wisconsin | 2.1 | 3.6 | 7.3 | 22.1 | .......... | .......... | 6.0 |
| Minnesota | 1.0 | 3.0 | 4.6 | 9.8 | 35.8 | 44.8 | 3.9 |
| South Atlantic: | | | | | | | |
| Delaware | .......... | 1.8 | 6.8 | .......... | .......... | .......... | 3.8 |
| Maryland | .......... | 5.0 | 4.9 | 12.2 | .......... | .......... | 6.5 |
| Virginia | .......... | .......... | 6.8 | 11.4 | 9.0 | .......... | 8.6 |
| West Virginia | .......... | 7.2 | 7.1 | 13.4 | 27.1 | .......... | 10.4 |
| North Carolina | .......... | .......... | 5.8 | 7.9 | 10.4 | .......... | 8.4 |
| South Carolina | .......... | .......... | 2.2 | 3.0 | 5.2 | 16.6 | 3.3 |
| Georgia | .......... | .......... | 3.9 | 5.8 | 14.0 | 21.2 | 6.2 |
| Florida (northern part) | .......... | .......... | 6.8 | 8.4 | 20.4 | 15.5 | 11.6 |
| South Central: | | | | | | | |
| Kentucky | 1.9 | 2.1 | 8.2 | 11.0 | 23.3 | .......... | 7.0 |
| Tennessee | .......... | .......... | 4.1 | 9.4 | 11.3 | .......... | 6.2 |
| Arkansas | .......... | .......... | 4.8 | 5.6 | 10.6 | .......... | 6.2 |
| Alabama | .......... | 2.3 | 3.1 | 5.5 | 7.9 | .......... | 4.4 |
| Mississippi | .......... | .......... | 2.1 | 6.5 | 8.6 | .......... | 4.8 |
| Louisiana | 1.5 | .5 | 2.4 | 4.5 | 11.8 | .......... | 3.4 |

The value to the individual farm of the woodlot products reported to the 1910 census averaged $81. In order to ascertain the approximate values per farm of the amounts which were either sold or consumed on the farm in the different woodlot divisions, 450 counties were chosen at random from the different divisions in each State. The total values for each county were divided by the number of farms reporting. On the average, less than half of all the farms reported, so that the average income, based on all the farms in the counties, would have been smaller. The average total value per farm reporting ranged, as a rule, from about $30 to over $400, smallest in the counties in woodlot Division I and largest in those in Division VI. The average values of the amounts used on the farms were exceedingly constant throughout the woodlot divisions. The values of the amounts sold, on the other hand, were naturally much the greatest in the thinly settled divisions. Table 10 gives the value per farm of the products used and sold in the selected counties, according to division and State.

**TABLE 10.**—*Average value per farm of woodlot products used on farm and those sold, in 1910.*

[Based on averages of census returns from 450 counties at random from each woodlot division in each State.]

| State or State group. | Value per farm reporting. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Division I. | | | Division II. | | | Division III. | | | Division IV. | | |
| | Total. | Used on farm. | Sold. | Total. | Used on farm. | Sold. | Total. | Used on farm. | Sold. | Total. | Used on farm. | Sold. |
| Eastern United States | **$69** | $47 | *$22* | **$74** | $47 | *$27* | **$80** | $42 | *$38* | **$93** | $42 | *$51* |
| New England | ...... | ...... | ...... | **76** | 40 | *36* | **130** | 52 | *78* | **162** | 58 | *104* |
| Middle Atlantic | **69** | 39 | *30* | **84** | 48 | *36* | **110** | 46 | *64* | **106** | 40 | *66* |
| North Central | **78** | 49 | *24* | **69** | 43 | *26* | **70** | 39 | *31* | **71** | 38 | *33* |
| Lake | **61** | 46 | *15* | **71** | 50 | *21* | **73** | 46 | *27* | **138** | 48 | *90* |
| South Atlantic | ...... | ...... | ...... | **112** | 66 | *46* | **65** | 39 | *26* | **81** | 39 | *42* |
| South Central | **75** | 62 | *13* | **54** | 45 | *9* | **66** | 39 | *27* | **64** | 36 | *28* |
| New England: | | | | | | | | | | | | |
| Maine | ...... | ...... | ...... | ...... | ...... | ...... | **119** | 47 | *72* | **141** | 56 | *85* |
| New Hampshire | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | **218** | 68 | *150* |
| Vermont | ...... | ...... | ...... | ...... | ...... | ...... | **149** | 66 | *83* | **197** | 82 | *115* |
| Massachusetts | ...... | ...... | ...... | ...... | ...... | ...... | **146** | 49 | *97* | **164** | 39 | *125* |
| Rhode Island | ...... | ...... | ...... | **76** | 40 | *36* | **128** | 51 | *77* | **136** | 32 | *104* |
| Connecticut | ...... | ...... | ...... | ...... | ...... | ...... | **107** | 46 | *61* | **177** | 49 | *128* |
| Middle Atlantic: | | | | | | | | | | | | |
| New York | **57** | 46 | *11* | **87** | 55 | *32* | **114** | 56 | *58* | **104** | 47 | *57* |
| New Jersey | ...... | ...... | ...... | **62** | 32 | *30* | **102** | 39 | *63* | **53** | 32 | *21* |
| Pennsylvania | **73** | 37 | *36* | **86** | 37 | *49* | **106** | 35 | *71* | **122** | 28 | *94* |
| North Central: | | | | | | | | | | | | |
| Ohio | **75** | 52 | *23* | **68** | 36 | *32* | **72** | 31 | *41* | **71** | 32 | *39* |
| Indiana | **79** | 40 | *39* | **85** | 47 | *38* | **66** | 27 | *39* | **55** | 32 | *23* |
| Illinois | **68** | 44 | *24* | **61** | 39 | *22* | **66** | 35 | *31* | ...... | ...... | ...... |
| Iowa | **75** | 55 | *20* | **63** | 50 | *13* | **78** | 59 | *19* | ...... | ...... | ...... |
| Missouri | **66** | 50 | *16* | **68** | 49 | *19* | **70** | 47 | *23* | **90** | 50 | *40* |
| Lake: | | | | | | | | | | | | |
| Michigan | **76** | 52 | *24* | **87** | 49 | *38* | **108** | 42 | *66* | **186** | 55 | *131* |
| Wisconsin | **60** | 47 | *13* | **67** | 54 | *13* | **81** | 54 | *27* | **156** | 47 | *109* |
| Minnesota | **52** | 40 | *12* | **63** | 45 | *18* | **53** | 36 | *17* | **92** | 49 | *43* |
| South Atlantic: | | | | | | | | | | | | |
| Delaware | ...... | ...... | ...... | **56** | 42 | *14* | **67** | 28 | *39* | ...... | ...... | ...... |
| Maryland | ...... | ...... | ...... | **150** | 93 | *57* | **81** | 46 | *35* | **136** | 50 | *86* |
| Virginia | ...... | ...... | ...... | ...... | ...... | ...... | **75** | 27 | *48* | **89** | 29 | *60* |
| West Virginia | ...... | ...... | ...... | **160** | 62 | *98* | **72** | 30 | *42* | **105** | 41 | *64* |
| North Carolina | ...... | ...... | ...... | ...... | ...... | ...... | **46** | 38 | *8* | **65** | 34 | *31* |
| South Carolina | ...... | ...... | ...... | ...... | ...... | ...... | **49** | 40 | *9* | **51** | 30 | *21* |
| Georgia | ...... | ...... | ...... | ...... | ...... | ...... | **62** | 56 | *6* | **82** | 62 | *20* |
| Florida (26 northern counties) | ...... | ...... | ...... | ...... | ...... | ...... | **118** | 60 | *58* | **188** | 87 | *101* |
| South Central: | | | | | | | | | | | | |
| Kentucky | **98** | 79 | *19* | **85** | 66 | *19* | **104** | 51 | *53* | **75** | 34 | *41* |
| Tennessee | ...... | ...... | ...... | ...... | ...... | ...... | **48** | 30 | *18* | **55** | 31 | *24* |
| Arkansas | ...... | ...... | ...... | ...... | ...... | ...... | **73** | 51 | *22* | **57** | 32 | *25* |
| Alabama | ...... | ...... | ...... | **32** | 30 | *2* | **58** | 37 | *21* | **59** | 36 | *23* |
| Mississippi | ...... | ...... | ...... | ...... | ...... | ...... | **34** | 27 | *7* | **62** | 44 | *18* |
| Louisiana | **30** | 29 | *1* | **47** | 41 | *6* | **109** | 54 | *55* | **102** | 47 | *55* |

TABLE 10.—*Average value per farm of woodlot products used on farm and those sold, in 1910*—Continued.

[Based on averages of census returns from 450 counties at random from each woodlot division in each State.]

| Division or State. | Value per farm reporting. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Division V. | | | Division VI. | | | Total. | | |
| | Total. | Used on farm. | Sold. | Total. | Used on farm. | Sold. | Total. | Used on farm. | Sold. |
| Eastern United States | $94 | $39 | *$54* | $232 | $51 | *$181* | $85 | $43 | *$42* |
| New England | | | | | | | 147 | 55 | *92* |
| Middle Atlantic | 122 | 44 | *78* | | | | 95 | 45 | *50* |
| North Central | 37 | 30 | *7* | | | | 69 | 42 | *27* |
| Lake | 187 | 51 | *136* | 325 | 61 | *264* | 83 | 47 | *36* |
| South Atlantic | 91 | 43 | *48* | 228 | 50 | *178* | 80 | 41 | *39* |
| South Central | 95 | 36 | *59* | | | | 70 | 38 | *32* |
| **New England:** | | | | | | | | | |
| Maine | | | | | | | 136 | 54 | *82* |
| New Hampshire | | | | | | | 218 | 68 | *150* |
| Vermont | | | | | | | 164 | 71 | *93* |
| Massachusetts | | | | | | | 149 | 47 | *102* |
| Rhode Island | | | | | | | 129 | 33 | *96* |
| Connecticut | | | | | | | 118 | 46 | *72* |
| **Middle Atlantic:** | | | | | | | | | |
| New York | | | | | | | 97 | 54 | *43* |
| New Jersey | | | | | | | 70 | 34 | *36* |
| Pennsylvania | 122 | 44 | *78* | | | | 95 | 35 | *60* |
| **North Central:** | | | | | | | | | |
| Ohio | | | | | | | 71 | 38 | *33* |
| Indiana | | | | | | | 73 | 36 | *37* |
| Illinois | | | | | | | 64 | 40 | *24* |
| Iowa | | | | | | | 71 | 54 | *17* |
| Missouri | 37 | 30 | *7* | | | | 66 | 46 | *20* |
| **Lake:** | | | | | | | | | |
| Michigan | 192 | 30 | *162* | | | | 99 | 48 | *51* |
| Wisconsin | | | | | | | 87 | 52 | *35* |
| Minnesota | 187 | 53 | *134* | 325 | 61 | *264* | 72 | 42 | *30* |
| **South Atlantic:** | | | | | | | | | |
| Delaware | | | | | | | 64 | 33 | *31* |
| Maryland | | | | | | | 109 | 55 | *54* |
| Virginia | 100 | 41 | *59* | | | | 83 | 29 | *54* |
| West Virginia | 380 | 93 | *287* | | | | 101 | 39 | *62* |
| North Carolina | 84 | 34 | *50* | | | | 69 | 35 | *34* |
| South Carolina | 80 | 46 | *34* | 455 | 81 | *374* | 62 | 38 | *24* |
| Georgia | 62 | 34 | *28* | 207 | 52 | *155* | 75 | 52 | *23* |
| Florida (26 northern counties) | 266 | 149 | *117* | 172 | 33 | *139* | 193 | 92 | *101* |
| **South Central:** | | | | | | | | | |
| Kentucky | 173 | 32 | *141* | | | | 101 | 44 | *57* |
| Tennessee | 64 | 25 | *39* | | | | 53 | 30 | *23* |
| Arkansas | 68 | 31 | *37* | | | | 64 | 36 | *28* |
| Alabama | 72 | 40 | *32* | | | | 57 | 36 | *21* |
| Mississippi | 84 | 40 | *44* | | | | 58 | 38 | *20* |
| Louisiana | 133 | 56 | *77* | | | | 104 | 50 | *54* |

Compared with other crops, woodlots need very little attention. The growth is laid on year after year without cultivation, and the occasional thinnings which are necessary to increase the growth of the better trees can be made to pay for themselves in cash or in wood for farm consumption. If mature trees are to be removed for sale, the work can be done at any time when other farm work is not pressing. An important feature is that farm labor and teams can thus be utilized during periods when otherwise they might be idle. In effect this increases the income to be expected from the woodlot and thus raises the value of the standing timber.

The attitude of farmers toward their woodlots probably differs a great deal in different regions. Those functions of the woodlot which are of most value at a given time and place are emphasized, and other valuable functions perhaps not recognized at all. Where agriculture is entering heavily wooded regions in which cleared land is at a premium and wood is cheap, timber is likely to be considered only an incumbrance, or at best as a means of eking out a livelihood until the cleared and cultivated land becomes sufficiently productive. In long-settled farming regions, where woodlots have been overcut, overgrazed, or repeatedly burned until only a few defective trees are left, the farmer may prefer to save the remnant simply for the shade it gives to stock or buildings, or for some sentimental reason. In prairie country, protection to grain crops, orchards, stock, or buildings, together with service as a convenient supply of wood for farm consumption may cause owners to place a high value on their woodlots. In mountainous regions near thickly populated manufacturing centers, as in New England, the woodlot may be valued for its wood-producing capacity alone. The temptation is to underestimate those functions of the woodlot which are not obviously beneficial under the conditions existing in the immediate locality. These less obvious functions are often the very ones which are likely to prove of the greatest value in the long run. For example, many of the Minnesota farmers who totally cleared their lands would be glad to have their woodlots back again if only for protective purposes, and farmers in the Central States already regret the abuse which has spoiled their woodlots as productive agents of increasing value on the poorer soils of the farm.

It is therefore greatly to the interest of all woodlot owners to consider thoroughly not only the present but the possible future usefulness of their timber from every point of view. Circumstances, such as the need of ready cash in "hard times," may, of course, make it necessary or advisable to sacrifice the woodlot, even though the loss to the farm is greater than the immediate cash income from the wood products. Clearing of excess woodlands is necessary when the soil can be put to a more paying use, for cultivation, pasture, or orchard. The point is that before cutting off his wood the farmer should carefully weigh its value, in all its phases, against the income which he can hope to make from the contemplated use of the soil. He should not clear, if he can help it, unless the balance stands unmistakably against the timber.

### HOME SUPPLY.

Most farms use yearly a great deal of wood, which must be bought if it is not taken from the woodlot. Firewood, lumber, fencing, and poles are the forms in which the woodlot material is most used, but there are many other products for special uses and emergencies which the woodlot supplies. Substitutes for wood are, of course, coming more and more into use. Rail fences have long been displaced in general use by wire fencing, and steel and cement fence posts are growing in favor in many regions. Coal is used for fuel, and concrete for construction. In general, however, the woodlot products have the advantage of cheapness and ready availability. The woodlot thus has a "convenience value" apart from its intrinsic value.

*Firewood.*—The largest "home use" of the woodlot is for firewood. In a study by the Office of Farm Management,[1] U. S. Department of Agriculture, of the ways in which the farm contributes to the farmer's living, the average amounts and values of wood and coal used on farms for fuel were determined for various States. The averages were based on satisfactory records obtained from 483 families visited, distributed fairly evenly through 10 areas in as many States, representative of the kind of agriculture practiced in the regions. For those of the 10 States covered which fall within the scope of the present bulletin the average amounts and values were as shown in Table 11.

TABLE 11.—*Average annual consumption of coal and wood on farms in eight States, with the proportion of wood bought and the proportion furnished by the farm.*[1]

[The amount of wood is expressed in the standard cord: that is, the amount contained in a pile 8 feet long by 4 feet high and 4 feet wide. This is equivalent to 3 cords of "stove-wood" (16-inch lengths).]

| State and county. | Coal. | | Wood. | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Per family. | | Per family. | | Per person. | | Bought. | Furnished by farm. |
| | Tons. | Value. | Cords. | Value. | Cords. | Value. | Per cent. | Per cent. |
| Vermont (Lamoille) | 0.1 | $1.01 | 14.3 | $65.40 | 3.0 | $13.62 | 3.0 | 97.0 |
| New York (Otsego) | 2.5 | 16.00 | 12.3 | 54.80 | 3.1 | 13.70 | 1.8 | 98.2 |
| Pennsylvania (Bucks) | 4.9 | 26.90 | 6.2 | 19.00 | 1.2 | 3.65 | 5.8 | 94.2 |
| Ohio (Champaign) | 5.7 | 23.70 | 12.0 | 32.50 | 2.9 | 7.93 | 6.2 | 93.8 |
| Wisconsin (Jefferson) | 3.0 | 20.70 | 7.5 | 38.80 | 1.1 | 5.34 | 7.7 | 92.3 |
| Iowa (Montgomery) | 3.9 | 29.57 | 4.8 | 22.40 | 1.7 | 8.82 | .......... | 100 |
| North Carolina (Gaston) | ........ | ........ | 14.0 | 43.58 | 3.1 | 9.68 | 3.9 | 96.1 |
| Georgia (Troup) | ........ | ........ | 17.8 | 51.60 | 3.3 | 9.56 | .......... | 100 |
| Average | 2.5 | 14.74 | 11.1 | 41.01 | 2.4 | 9.04 | 3.55 | 96.45 |

[1] From Farmers' Bulletin 635, "What the Farm Contributes Directly to the Farmer's Living," by W. C. Funk. See also Department of Agriculture Bulletin 410, "Value to Farm Families of Food, Fuel, and Use of House," by W. C. Funk.

Though the number of farms which supplied the data was not large, the fact that they were taken at random lends value to the table as an indication of the usefulness of the woodlot for fuel not only in these States but in the other Eastern States also. A great many farmers use coal for fuel, but there are probably very few who depend entirely upon it. In only two States—Pennsylvania and Iowa—did the amount spent for coal exceed that spent for wood. In Pennsylvania this was probably due to the ready availability and cheapness of coal; in Iowa, to the relative scarcity of wood. The proportion of wood furnished by the farms on which it was consumed is significant. This averaged over 96 per cent, and the remainder—less than 4 per cent—was probably bought from adjacent farms. In the two Southern States that appear in the table, approximately three-fifths of all the wood was used in fireplaces. The other two-fifths was used in cookstoves.

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[1] Department of Agriculture, Farmers' Bulletin 635, "What the Farm Contributes Directly to the Farmer's Living," by W. C. Funk.

The heating value of coal is, of course, much greater than that of wood. Forest Service investigations[1] show that in general 1 pound of coal has a heating value equivalent to 2 pounds of seasoned wood. Allowing 80 cubic feet of solid wood to a standard cord (4-foot sticks in a pile 8 feet long and 4 feet high), the weight of a cord of the heavy, medium, and light woods would be about 4,000, 3,000, and 2,000 pounds, respectively, for seasoned sticks containing 15 or 20 per cent moisture. Table 12 shows the number of cords of several kinds of seasoned wood that are necessary to give approximately the same heating value as 1 ton of coal.

TABLE 12.—*Amount of wood of different species necessary to give the heating value of 1 ton of coal.*

| 1 cord of wood equivalent to 1 ton of coal. | 1½ cords of wood equivalent to 1 ton of coal. | 2 cords of wood equivalent to 1 ton of coal. |
|---|---|---|
| Hickory. | Shortleaf pine. | Cedar. |
| Oak. | Western hemlock. | Redwood. |
| Beech. | Red gum. | Poplar. |
| Birch. | Douglas fir. | Catalpa. |
| Hard maple. | Sycamore. | Norway pine. |
| Ash. | Soft maple. | Cypress. |
| Elm. | | Basswood. |
| Locust. | | Spruce. |
| Longleaf pine. | | White pine. |
| Cherry. | | |

There are other factors besides heat value which affect the usefulness of the different kinds of wood for fuel. Pine, for example, has a relatively low heat value per unit volume, but it ignites readily and gives out a quick, hot flame which soon dies out. This makes it a favorite with rural housekeepers, because it is particularly adapted for hot days in the kitchen. Hickory has the highest heat value, burns evenly, and "holds the heat." Oaks come next in this respect, followed by beech, birch, and maple. In selecting wood for fuel, however, it is important to consider the much greater value which some of the species have for other uses. It is a mistake to burn young, sound hickory and oak except when removed to improve the stand or to make way for cultivation of the land. Usually, too, these and many other species can be sold at prices which make it unwise to use them for fuel. It is better to make the farm firewood out of the species that are less salable.

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[1] "Fuel Value of Wood," by H. S. Betts and Earnest Bateman; mimeographed circular of the Forest Service, 1913.

*Lumber.*—It is probable that much more of the lumber used in farm buildings is bought in the general market than is sawed from woodlots. A considerable amount of woodlot material still goes into buildings, however, especially in the newer agricultural regions. It is here that the economy of the woodlot appears to good advantage. At times when farm work is not pressing, as in the winter, the farmer can saw enough of his trees into logs to make the required amount of lumber, haul them to some nearby mill which does "custom sawing," and have them manufactured into lumber for $3 or $4 per thousand board feet. Since at certain seasons of the year the men and teams of the farm are apt to be free from other work, the cost of the labor involved is a negligible item. The saving may thus amount to as much as two-thirds or three-fourths of the cost of even the lower grades of lumber available on the general market.

As a rule, however, the woodlot affords only a small amount, if any, of the kinds of lumber which ought to go into buildings. It is common to find farmers putting various hardwoods into barn lumber. The loss is a double one. Hardwood lumber is much less adapted to building than softwood, like pine or hemlock. The work is harder and the building less satisfactory. At the same time some of the hardwoods are especially fitted for uses for which softwoods can not be employed, and when markets are available the farmer may be able to sell his best hardwood logs or lumber at a high price, more than sufficient, possibly, to pay for the amount of softwood lumber needed. Where the market for hardwood material is poor, however, and even in some cases when it is good, the possibility of utilizing idle teams may justify the farmer in putting his hardwood logs into building lumber. When the woodlot contains softwood timber the saving is unquestionable.

### PROTECTION.

If trees on the farm gave no wood for home consumption and none for sale their value for protection and shelter alone would often be great enough to justify their preservation. In the Northern States, where cold winter winds are a source of discomfort or damage, the woodlot goes a long way toward increasing the comfort of farm life. Even when leafless, a small woodlot will break the force of a strong wind; and in summer, when the leaves are on the trees, the obstruction to wind is much greater. Both live stock and crops benefit from protection against hot, drying winds.

For crop protection the woodlot must be properly located. In the absence of native timber, windbreaks, which are woodlots in narrow strips, were extensively planted for crop protection by the early settlers in the great plains region. The results did not look satisfactory to the farmers, because it was noticed that near the windbreak the grain was stunted and poor, and a revulsion of feeling against timber belts took place. There is not so much planting as formerly, and in one State—Kansas—legislative action has been taken providing that all hedge fences along the public highway shall be cut and trimmed to not more than 5 feet high, except when protecting orchards, vineyards, and feed lots.[1]

To find out as accurately as possible the relation between benefit and injury to farm crops from windbreaks, a detailed study of this subject was made in 1908 by the Forest Service.[2] Careful measurements were made at different distances from windbreaks of various species to determine, on the one hand, the amount of harm done to adjacent crops by shading, the sapping of soil moisture, and other causes; and on the other hand, the amount of benefit due to protection from evaporation, the breaking of the mechanical force of the wind, etc. At the same time, the solid contents of the trees were measured and their value as wood determined. The results of the study showed a good deal of variation among windbreaks of different species and different degrees of density, and between rows running in north-and-south as compared with east-and-west directions. In general they showed that while dense windbreaks do considerable damage to crops standing close to them—to a distance of once or twice the height of the tree—their protection from drying winds will ordinarily increase the grain yields farther away, to a distance of 10 or 12 times the tree height—more than enough to make good the loss. The protection is especially noticeable after heavy winds, which in the absence of efficient windbreaks often ruin entire fields of grain. The greatest direct benefit is obtained when the windbreaks are not closer together than a distance equal to twenty times their height. Orchard trees close to windbreaks are injured by shading and sapping, while those farther away are benefited by protection from breakage, drought, and freezing.

The economic value of windbreaks is determined not only by the prevalence of damaging winds in a region, but also by climatic factors affecting the growth of the trees themselves and the productiveness of the windbreak as a source of timber supply. Windbreaks very commonly occupy soils of agricultural value; and since an effective windbreak must consist of more than a single row of trees, the area occupied is considerable. This should be considered in starting windbreaks. Planting them on an extensive scale to protect large areas is justified when their combined protective and timber value can be expected to equal or exceed the value of field crops which might be grown on the same area.

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[1] General Statutes of Kansas, 1901, secs. 3116–3118. The adoption of this statute is left to popular vote in each county.

[2] "Windbreaks: Their Influence and Value," by C. G. Bates, Forest Service Bulletin 86, 1911; and "The Windbreak as a Farm Asset," by C. G. Bates, Farmers' Bulletin 788.

The relative value of the direct and indirect benefits of timber units is determined by the moisture conditions of the climate. Where, as in all the eastern States except parts of the Lake States and most of Iowa, the annual precipitation is over 30 inches, the crop protection is small, and windbreaks may be positively injurious around poorly drained farm land, but for orchard and home protection their value may be great enough to justify their existence, even without considering their wood-producing value. Where the annual precipitation is less than 30 inches the value of protection to crops is likely to be greater.

### AS A POOR-LAND CROP.

On poor soils and on slopes too steep for successful cultivation, timber affords an excellent means of getting at least a moderate income. One objection often raised against woodlots is that trees take too long to mature, so that the owner can not hope to realize on his investment if it involves raising the stand from its youth. Even if the wood crop can be harvested only once in a lifetime, however, a net income may often be obtained which will represent as high an interest rate on the investment as other farm crops raised on better soils.

There are two general ways of managing a timber crop, depending upon whether the woodlot is to be maintained for its indirect benefits to the farm, the wood yield being a secondary but important object, or whether it is to be managed primarily as a wood-raising investment. In the first case, the farmer would keep his woodlot intact, cutting a few trees here and there as they reached large, merchantable size, and supplying himself with fuel from their branches and from defective or crowded trees removed from time to time to keep the stand in a good, rapid-growing condition. If care is taken to prevent overcutting, overgrazing, and fire, and if a good undergrowth of desirable species is encouraged, the stand can thus be perpetuated indefinitely, and the farmer can afford to raise some trees of high value but slow growth, like hickory and white oak, as well as large trees of more rapid-growing species, like black walnut and yellow poplar. If financial profit from the sale of wood products is the chief aim, a safe margin of income over all costs of raising and marketing must be reasonably certain. The cost of raising timber includes planting (if this is done), subsequent upkeep, and taxes. In addition, some charge must be made against the use of the land, which is small in situations not adapted to cultivation. As a rule the cost of raising timber is very small compared with the cost of raising other farm crops. Where a young stand already exists and no planting expense is involved, there are several species of trees which will yield a profit provided they are adapted to the soil and climate. Within a moderate hauling distance of a steady market for wood products, as in parts of New England, planting can be and is practiced on lands of low agricultural value with fair assurance of a good profit.[1]

Under average conditions it has been shown that a few of the best species for woodlots, raised from seedlings to financial maturity on land worth $5 or $10 per acre, should yield incomes at the following rates of compound interest:[2]

| | Per cent. |
|---|---|
| Cottonwood, on favorable soils | 6 or 7 |
| Loblolly pine, on the most favorable soils | 2 to 11 |
| Loblolly pine, on less favorable soils | 0.8 to 5 |
| White pine, on the most favorable soils | 4 to 10 |
| White pine, on less favorable soils | 2 to 7 |
| White ash, on favorable soils | 5 to 10 |

These rates vary chiefly with the distance from market and the prices which can be obtained for lumber of the qualities supplied. The closer the stand is to the market the higher the lumber prices to be expected; and the better the soil and moisture conditions for rapid growth the higher will be the interest rate on the investment. Even the lower interest rates indicated above compare favorably with crop incomes in many farming regions.[3]

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[1] In choosing between species to be planted or favored in woodlots the two qualities to be sought are rapidity of growth under the existing conditions of soil and climate and high market value when cut. Since the market value can not be estimated in advance with accuracy, rapidity of growth is the more important consideration; but of two rapid-growing species the one whose wood seems likely to fill the greatest variety of industrial needs should, of course, be chosen. The time when the timber must be cut in order to yield the highest net profit is that at which the greatest difference exists between the sale value of the products and the accumulated cost, at compound interest, of planting, care and protection, and taxes. Compared with the great age which many kinds of trees reach in nature, this period of "financial maturity" comes early. It is commonly attained at from 40 to 60 years of age, though sometimes earlier with rapid-growing species on good soil and later with slower-growing species on poor soil. With especially rapid-growing species, like loblolly pine, the rotation of maximum income may be as short as 20 years under the best conditions. Information relating to tree species for woodlot use is contained in detail in Department of Agriculture Farmers' Bulletin 711, "The Care and Improvement of the Woodlot," which can be secured on application to the Secretary of Agriculture, Washington, D. C.

[2] This subject is treated at length, for various species, in the following bulletins of the Department of Agriculture:

Bul. 11, "Forest Management of Loblolly Pine in Delaware, Maryland, and Virginia."
Bul. 13, "White Pine Under Forest Management."
Bul. 24, "Cottonwood in the Mississippi Valley."
Bul. 299, "The Ashes: Their Characteristics and Management."

[3] See Department of Agriculture Bulletin 41, "A Farm-Management Survey of Three Representative Areas in Indiana, Illinois, and Iowa," by E. H. Thomson and H. M. Dixon.

The care of woodlots requires practically no work beyond the amount necessary to get out the year's supply of firewood, posts, etc., which, as thinnings and "improvement cuttings," may be made to improve the condition of the stand. The value of wood cut and sold therefore comes nearer to being a net value than that of grain crops, a large part of which each year is the cost of labor. While the gross returns per acre from most crops are usually larger than from wood the two are really much closer together when the labor cost is deducted. Furthermore, the woodlot is ready for cutting at any season, so that farm labor can be utilized on it when unoccupied with other farm work, as in the winter. There is little risk of loss from wind storms, heavy rains, hail, frosts, or droughts; and, in addition, the farmer has the advantage of wood for farm use ready at hand, of protection to adjacent crops, to stock, and, possibly, to buildings, and of by-products which the woodlot affords, such as maple sugar, nuts, etc., all of which tend to increase the selling value of farm property.

The value of land which can be used for woodlot purposes, judged from the standpoint of wood production alone, would be the capitalized value of the net income to be expected each year. The computation is practically the same as for any field crops. It consists simply in dividing the estimated net annual income by the desired rate per cent. In the following table net incomes of from 25 cents to $3 per acre per year are capitalized at 3, 4, 5, and 6 per cent, and the result in each case represents the true valuation of the land which will produce the corresponding net annual income per acre:

**Table 13.**—*Values of land for wood raising, representing net annual incomes of various amounts capitalized at 3, 4, 5, and 6 per cent.*

| Net income per acre per year from the woodlot. | Land values, capitalized at— | | | |
|---|---|---|---|---|
| | 3 per cent. | 4 per cent. | 5 per cent. | 6 per cent. |
| $0.25 | $8.33 | $6.25 | $5.00 | $4.17 |
| $0.50 | 16.67 | 12.50 | 10.00 | 8.33 |
| $0.75 | 25.00 | 18.75 | 15.00 | 12.50 |
| $1.00 | 33.33 | 25.00 | 20.00 | 16.67 |
| $1.50 | 50.00 | 37.50 | 30.00 | 25.00 |
| $2.00 | 66.67 | 50.00 | 40.00 | 33.33 |
| $2.50 | 83.33 | 62.50 | 50.00 | 41.67 |
| $3.00 | 100.00 | 75.00 | 60.00 | 50.00 |

Since the net income is only the amount remaining after deducting all costs of labor, interest, taxes, etc., it is not an easy figure to determine. It depends also upon the amount of wood produced each year on each acre of woodlot, which is the amount that could be removed without cutting into the producing capital of the woodlot. For example, a farmer finds out that his wood is growing at the rate of 2 cords of "stove wood" (16-inch lengths) per acre per year and proceeds to cut and sell this amount each year. Although he does the cutting and hauling at times when his men and teams would otherwise be idle, he decides to figure the cost as though he actually paid to have the work done and finds the cost to be $3.50 per cord, delivered. He sells his wood at the rate of $4.50 per cord, clearing $1 on each cord sold. Since the annual growth per acre is 2 cords the income amounts to $2 per acre. Arbitrarily deducting 50 cents to cover one year's taxes and interest per acre, the remainder, $1.50, represents his net income. Capitalizing this at 5 per cent (see Table 13) he finds that the producing value of his land for the wood crop is $30 per acre. A very little figuring of the costs and values of other crops which might be raised on the same soil will enable him to decide whether, from a standpoint of direct income only, he is justified in keeping the land under timber. The indirect values already discussed should, of course, greatly influence his decision.

The possibilities in regard to marketing the products of the woodlot naturally differ a great deal in different regions.[1] They are best, as a rule, in thickly settled regions, where there are good roads and railroads, a large variety of manufacturing plants using wood, and better chances for securing competitive bidding for the products in the woodlot. Industries manufacturing cooperage, handles, spokes, hubs, basket and box veneer, novelties, spindles, etc., often present a better market for logs and short bolts than could be obtained if the trees were sawed up for lumber; although good logs of oak, yellow poplar, basswood, etc., may bring high prices at established mills for the production of high-grade lumber for furniture, finish, patterns, and other uses. Plants manufacturing special articles often employ buyers skilled in judging timber for the use for which they wish it, who travel through the farming sections buying individual trees or even woodlots. Though it is rarely possible for the farmer to become equally proficient, it is at least to his advantage before selling to inform himself on the best paying uses for his timber, the points which influence its value for these uses, and the factors which should determine the price to be paid, such as the distance and kind of haul to the manufacturing plant, the prevailing market prices, etc. It is, of course, always advisable to obtain as many competitive bids as possible, and in doing this it often becomes possible to sell to several different buyers, each taking from the woodlot the species or form of product he especially desires and can pay the most for.

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[1] Farmers are usually much better versed in selling other farm crops than in selling wood, and so when the wood crop is sold the problems which are involved in getting the best returns from it are likely to be perplexing. Furthermore, when the wood crops are many years apart the success of the undertaking depends a great deal more on getting a good price for the product than is the case with ordinary crops, with which a single bad bargain will affect only a single year. Before selling woodlot material, therefore, the farmer ought to obtain all the information possible on the following points: The local and distant markets and the shipping rates to them; the prices which different markets will pay for the same kind of timber, together with the specifications of each market as to size, shape, and quality; the cost of getting out the products (whether or not the farmer expects to do his own logging); and an estimate of the amount of different kinds of standing timber in his woodlot in the most profitable units (that is, as board feet of logs or lumber, cords of bolts or bark, and number of ties, poles, posts, etc.). Through ignorance of these things many farmers have sold timber far below its real worth, while others have held stands for excessively high prices until their best trees became practically worthless through decay.

The procedure which should be followed in making sales from woodlots is not within the scope of this bulletin, but is discussed in detail in Department of Agriculture Farmers' Bulletin 715, "Measuring and Marketing Woodlot Products." In most of the eastern States free information is also available on application to the State Foresters or to the State Agricultural Experiment Stations. In some States bulletins on marketing woodlot products within the State are available.

In the pioneering regions the market for woodlot products is much more limited and the prices are lower; but in spite of this the woodlot sales, as shown in Table 10, have amounted to more in these regions, through the extensive clearing practiced, than in the more settled regions. Freight rates to the more settled regions are high, and the farmers must sell, as a rule, to saw or pulp mills not very far away, delivering their logs or bolts to points along the railroad. Excelsior and box factories in these regions often buy large quantities of small or low-grade material from farmers, while lime and brick kilns take a great deal of cheap fuel wood at a small price. These small returns, however, may be indispensable to the settler for maintaining a living until crops can be grown on the land cleared.

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UNITED STATES DEPARTMENT OF AGRICULTURE
**BULLETIN No. 482**
OFFICE OF THE SECRETARY
Contribution from the Office of Farm Management
W. J. Spillman, Chief

Washington, D. C. ▼ February 19, 1917

# FARMING IN THE BLUEGRASS REGION.

## A Study of the Organization and Management of 178 Farms in Central Kentucky.

By J. H. Arnold, *Agriculturist*, and Frank Montgomery, *Scientific Assistant*.

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## INTRODUCTION.

The purpose of this bulletin is to present a general description of the farm-management practices followed on farms in the bluegrass region of Kentucky and to determine from analyses of the operations on about two hundred such farms the relative efficiency of the different types of farming in vogue and the factors which seem to have the greatest influence on farm profits in that locality.

It was found that specialized farms, those of the tobacco, stock, or dairy type, moderately diversified, are the most efficient in this region and that the general mixed farms, more highly diversified, are the least efficient. Thus, while diversity has a vital relation to profits here as elsewhere, it would appear that in the bluegrass region these spcialized farms have found in moderate diversity the right degree for maximum profit.

Of the factors which determine profit, size of business was found to have the greatest weight, with utilization of pasture and yield of field crops per acre important secondary factors. Size of farm has here no direct bearing upon labor income. It does, however, determine the character of the farm organization, the small farms naturally turning more to the cultivation of tobacco and the large farms to grazing.

## METHOD OF STUDY.

The farms selected to furnish the basis of study are located in three counties—Mason, Scott, and Madison. These counties are typical of the different parts of the region. They are widely separated. Mason lies on the Ohio River, Scott is near the center of the region, while Madison lies at the foot of the mountains and is representative of the more distinctly stock type of farming. Tobacco and live stock are important enterprises in all the counties studied. These two enterprises furnish the bases of all the types of farming found, with the exception of 10 distinctly dairy farms, which have not been included in the general analysis.

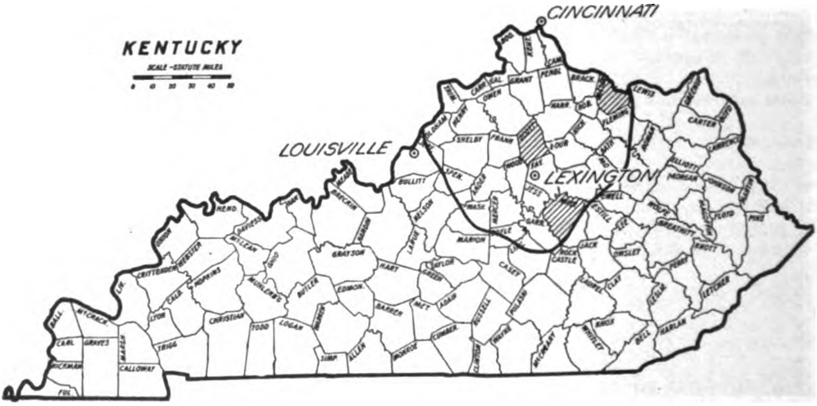

FIG. 1.—Map of Kentucky with bluegrass area outlined and the three counties in which farm records were taken shaded.

The farms visited were those named by various men in the community as being operated on a business basis. It was thought advisable also to select such farmers as were both willing and competent to give a record of a year's business, March 1, 1913, to March 1, 1914. Many of the farms were visited twice and many three times. In a preliminary survey about 25 complete records of each enterprise in the county were taken in order to determine the average seasons in which various operations were carried on and the amount of labor and horse work required for each. At the same time, farmers' estimates were secured as to the number of days available for field work in each month of the year. In the general survey that followed, each farmer furnished a year's record of his business and such other data as would be necessary in making a complete analysis of the business organization of the farm.[1]

## GENERAL DESCRIPTION OF REGION.

The bluegrass region borders on the Ohio River and occupies a somewhat circular area about 100 miles in diameter. (See fig. 1.) It is bounded by a rim of low mountains and the Ohio River. Lexington, a city of about 40,000, is southeast of the center. Richmond, Winchester, Paris, Georgetown, Versailles, and Nicholasville are the county seats of adjoining counties. All of these, except Richmond and Winchester, are connected with Lexington by trolley. Frankfort, the capital of the State, 22 miles west, is also connected with Lexington by trolley. All towns of importance throughout the region are connected by steam railways.

Throughout the region connecting the main towns and villages are macadamized roads, many of them kept in excellent repair.

Three main railway systems center at Lexington, connecting with the main large market centers of the interior and with all large seaboard cities on the Atlantic and the Gulf of Mexico.

The Kentucky River rises in the mountains of the southeastern part of the State and takes a winding course through the central portion of the area. Small steamers and rafts ply this river throughout its course in this region.

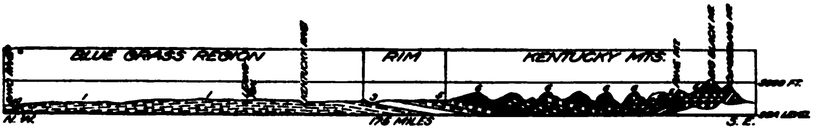

FIG. 2.—Cross-section of Kentucky, including the bluegrass region, indicating the topography and the elevations above sea level.

The topography in most parts, except in the vicinity of streams, is gently rolling. (See fig. 2.) The area is largely cleared of forest trees and 85 to 90 per cent is tillable. Farms vary in size from 40 to 1,000 acres or more. The country generally looks prosperous. Most farms are well kept up and many farmsteads have luxurious appointments and surroundings. (See fig. 3.) Formerly, the plantation type of farm prevailed and the work was almost entirely done by slaves. There is now a tendency toward subdivision into smaller farms. However, many are still large and are run on the plantation plan, with hired laborers or share tenants, mostly colored, who live on the farm in cottages and are provided with gardens and a few other perquisites.

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[1] Acknowledgment is due Messrs. B. F. Creech, Will D. Click, William Ballinger, L. C. Caldwell, and A. B. Thomas for collecting data for this bulletin; also to Prof. J. S. Pullen, of the Eastern Kentucky Normal School, who assisted in collecting data in Madison County and gave valuable help in other ways. The cordial interest of the farmers who gave the records is much appreciated, and thanks are due them for the time given to this work.

Many of the people who settled in this region brought with them from Virginia, and a few from the Carolinas, the fine traditions of the country house and the gentleman farmer. They had the same interests in the breeding of high quality of live stock which has long characterized the English farmers. Many dwellings were built in a substantial manner, often of brick. (See fig. 4.) Most of these still stand and give the country an atmosphere of ease, comfort, and sometimes luxury.

A great many of the farms are still owned and operated by those who inherited them from the original owners. There is reason to believe that the present owners are farming in the same spirit as their ancestors and with as good success.

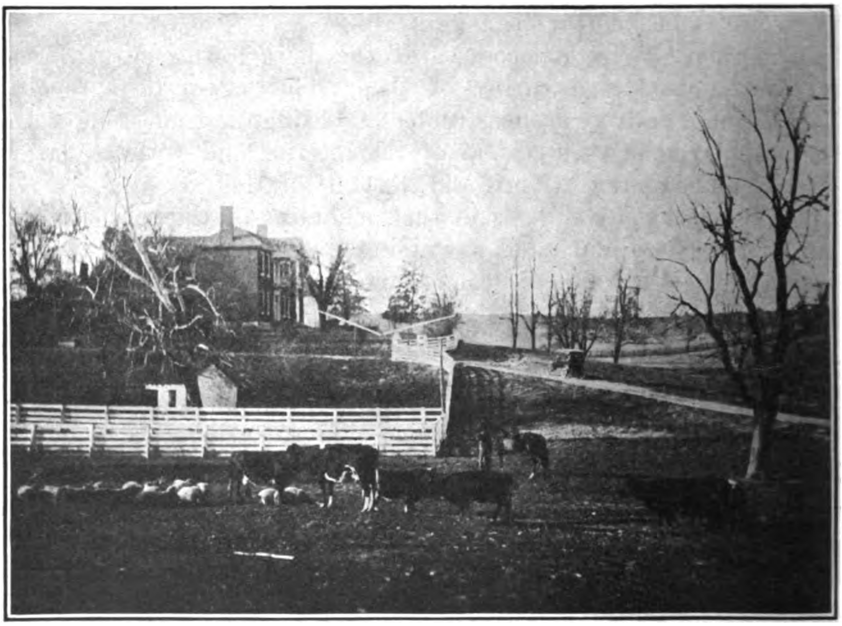

FIG. 3.—A typical bluegrass farmstead.

A few tracts have been bought up and are operated on a showy and expensive scale, with probably very little, if any, profit to the owners.

Tobacco culture enables the small-sized farm to carry a comparatively large business, so that there are many prosperous farms 40 to 100 acres in size.

In traveling through the country for the first time one is impressed by the large proportion of farm area in bluegrass pasture. Over the fields are scattered fine forest trees, providing shade for stock. These large areas in pasture and scattered trees suggest that the farmers devote their attention largely to live stock. The bluegrass farmer is prejudiced in favor of live-stock farming and will cling to it as a type as long as he can. Next to live stock in importance is the white Burley tobacco, a crop well adapted to the region, so that these two enterprises characterize this section agriculturally and are at present the main sources of income.

## HISTORY OF BLUEGRASS FARM ENTERPRISES.

It is a well-known fact that the acreage of crops varies from year to year because of the variation in prices. The amount of live stock kept on farms varies also for the same reason. Prices for a product in one section are, as a rule, made permanently lower than the cost of production if the same can be produced in another section at a lower cost and in adequate quantities. Again, by experience or through discovery, a more profitable enterprise may be substituted for another. Any of these causes or a combination of them will result in relatively permanent changes in the agriculture of a region. Tables I and II give a history of the several enterprises developed in this region from 1840 to 1910 according to figures of the United States census. These figures show that the agricultural resources here were well developed as early as 1840 and that their total production was not far behind that of 1910. Changes in the relative importance of the several enterprises, however, have occurred. Swine, for instance, were much more important prior to 1860 than at

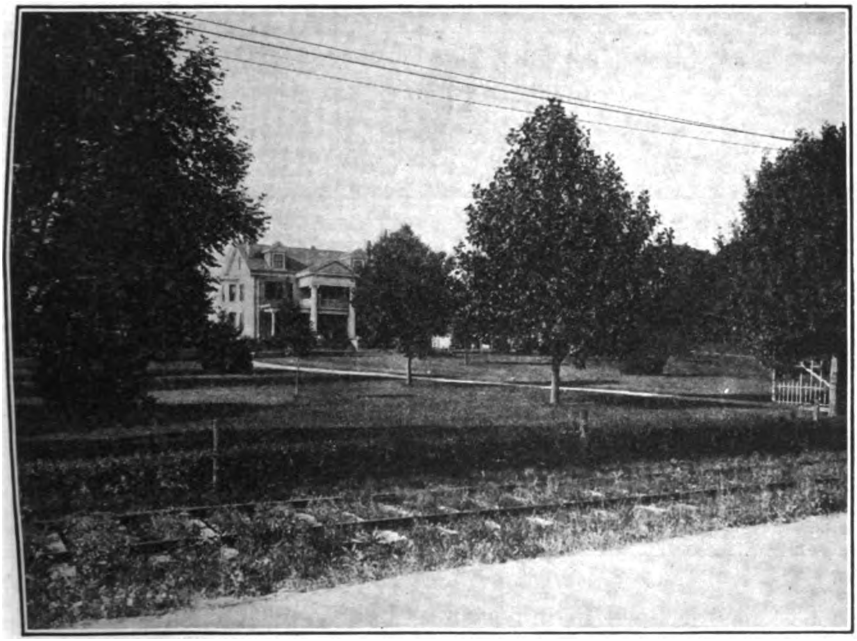

FIG. 4.—Type of the large modern farm house.

any time since. Before this time large droves of hogs were taken across the mountains into those sections of Georgia and the Carolinas which were devoted to raising cotton. This fact no doubt largely accounts for the comparatively large number of swine at that time. The development of railways and the opening up of the rich corn States farther west and north has also had an influence in changing the status of this enterprise. About the same amount of corn is raised as formerly, but most of it is fed to beef cattle and comparatively little to hogs.

**TABLE I.**—*Live-stock enterprises in the bluegrass region of Kentucky, 1840–1910 (Madison, Mason, and Scott Counties).*

| Year. | Horses. | Sheep. | Swine. | Total cattle. | Milch cows. | Other cattle. | Working oxen.[1] |
|---|---|---|---|---|---|---|---|
| 1840 | [2] 23,704 | 59,926 | 116,244 | 33,419 | ........ | ........ | ........ |
| 1850 | 17,292 | 58,327 | 115,122 | 38,836 | 11,568 | 27,268 | 3,288 |
| 1860 | 22,160 | 37,916 | 103,553 | 40,385 | 12,585 | 27,800 | 4,156 |
| 1870 | 14,817 | 25,179 | 65,095 | 35,761 | 10,504 | 25,257 | 2,624 |
| 1880 | 16,528 | [3] 45,753 | 75,980 | 40,207 | 11,495 | 28,712 | 1,598 |
| 1890 | 20,074 | 67,439 | 75,662 | 45,810 | 12,266 | 33,544 | 1,374 |
| 1900 | 18,721 | 87,778 | 62,476 | 59,989 | [4] 12,215 | 47,774 | ........ |
| 1910 | 19,193 | 88,177 | 63,969 | 47,591 | [4] 13,054 | 34,537 | ........ |

[1] Included under "Other cattle."

[2] Includes mules.

[3] Exclusive of lambs.

[4] Dairy cows.

**TABLE II.**—*Field crop enterprises in the bluegrass region of Kentucky, 1840–1910 (Madison, Mason, and Scott Counties).*

| Year. | Corn. | Wheat. | Rye. | Barley. | Oats. | Hay. | Hemp. | Tobacco. |
|---|---|---|---|---|---|---|---|---|
| | *Bushels.* | *Bushels.* | *Bushels.* | *Bushels.* | *Bushels.* | *Tons.* | *Pounds.* | *Pounds.* |
| 1840 | 2,230,880 | 367,668 | 178,092 | 8,000 | 347,941 | 9,670 | 2,356 | 1,248,032 |
| 1850 | 3,492,435 | 135,125 | 35,759 | 71,827 | 383,004 | 9,121 | 3,471 | 2,553,333 |
| 1860 | 3,536,996 | 541,304 | 99,094 | 77,291 | 388,390 | 9,639 | 528 | 1,804,593 |
| 1870 | 2,453,681 | 174,469 | 130,495 | 43,364 | 209,394 | 9,794 | 1,549 | 1,642,656 |
| 1880 | 3,123,212 | 837,172 | 71,454 | 81,663 | 98,014 | 7,980 | 348 | 6,452,093 |
| 1890 | 3,593,338 | 708,740 | 43,648 | 15,745 | 225,102 | 28,762 | 853 | 7,185,519 |
| 1900 | 2,754,770 | 702,240 | 17,100 | 728 | 66,730 | [1] 33,315 | 283,090 | 16,794,630 |
| 1910 | 3,475,775 | 332,181 | 21,941 | 2,710 | 63,058 | 41,821 | 342,450 | 23,688,291 |

[1] Hay and forage.

Rye has declined in importance sharply since about 1870. This crop is no longer profitable, except for early spring pasture and to turn under.

Barley also has declined in importance since about 1880, many farmers having forgotten that it was ever raised here.

Only about one-sixth as much oats is now raised as during the period before 1860. This crop also is unprofitable because it is produced in the States north and west at a very much lower cost per bushel than here. Most of the oats is now either cut and fed to horses in the bundle or is made into hay.

Tobacco has steadily increased in importance since about 1870 and is to-day one of the major enterprises. This is a crop that utilizes family labor to great advantage, and, as has been pointed out, is peculiarly adapted to the climate and soil.

Satisfactory historical figures on beef cattle and saddle horses can not be gleaned from census records, since cattle have been classified differently in the various census years. Beef cattle, though still numerous, are less important than formerly. About 1890 there was a dropping off not only in the number of beef cattle, but also in the number of all cattle. The saddle and driving horses of the bluegrass region have long been noted, but economic changes have occurred to make them less profitable. Mules, however, have largely filled up the ranks, so that to-day there are about the same number of animals of the horse kind as formerly. It is interesting to notice the gradual decline in the number of working oxen. Horses and mules have almost entirely taken the place of cattle as work stock.

## ROTATION OF CROPS.

No well-defined system of crop rotation prevails in the bluegrass region. The common custom, however, is to plant corn or tobacco on sod land. Much of the best tobacco land is obtained by breaking up old bluegrass sod or new land. Two crops of tobacco are very seldom grown in succession on the same land, while two successive crops of corn are grown on from one-fourth to one-half of the corn area, the rest of the corn and tobacco being followed by a small-grain crop, usually wheat. Generally clover and timothy and occasionally bluegrass are sown with cereal crops. Hay is then cut usually 1 or 2 years.

The great irregularities in rotation are caused by the length of time the land remains seeded down. Occasionally a field will be sown to clover and turned again at the end of the year. If timothy or other grass seeds be sown the land may remain in grass several years, and if a good bluegrass sod develops it may remain in pasture 30 to 40 years. The more common practice, however, is to leave rotation crop land seeded down from 2 to 5 years.

The type of farming practiced seems to influence the crop rotation to some extent. On the tobacco farms corn follows corn least frequently, and the land seldom remains in grass more than 3 years. As the farms increase in size through the various types to the large stock farms with no tobacco, two crops of corn in succession will be raised on about 50 per cent of the corn land, and the time the land remains seeded down lengthens to from 3 to 6 years and frequently longer. The rotation period for the stock farms, therefore, generally ranges from 5 years to 9 or more years.

## SOIL.

The soil of the bluegrass country is derived from limestone which is comparatively rich in lime phosphate. The typical bluegrass soil is reddish-brown or chocolate color. According to the United States

Bureau of Soils, it belongs to the series known as Hagerstown clay loam. It is of the same general type found in the Nashville Basin, East Tennessee Valley, and the Valley of Virginia. Except in the hilly parts along the rivers, rock is only occasionally seen on the surface. Generally it lies 2 to 20 feet below the surface, offering little obstruction to plows and other machinery. The subsoil in most places is a sticky red clay, highly retentive of moisture. While to the ordinary observer the soil seems quite uniform in fertility, the analyses by soil chemists show a good deal of variation, even in the most fertile sections.[1]

The farmers who have grown up in the region and have had experience with soils recognize many degrees of fertility. They distinguish the quality of tobacco soils especially by native trees that grow on the land. For instance, white oak, beech, walnut, maple, and hickory clearings have been favored for the production of the best quality of tobacco.[2]

## CLIMATE.

The organization of crop enterprises is greatly influenced by climate. Figure 5 is a diagram showing the main facts about the climate of this section. The rainy season is during the winter, the highest average rainfall occurring in March. During the hot period of summer the average rainfall is sufficient on this type of soil to keep tilled crops growing vigorously, but if it were not for the fact of a deep, heavy clay loam, rich in phosphorus, the region undoubtedly would not be famous for bluegrass, since a relatively low rainfall during the summer and fall is in itself injurious to bluegrass pasture. The farmers here expect frequent dry spells, when there is a shortage of pasture and water, and have adapted their farm practice and systems of farming to these conditions. Tobacco is one of the best drought-resistant plants known. For stock water farmers

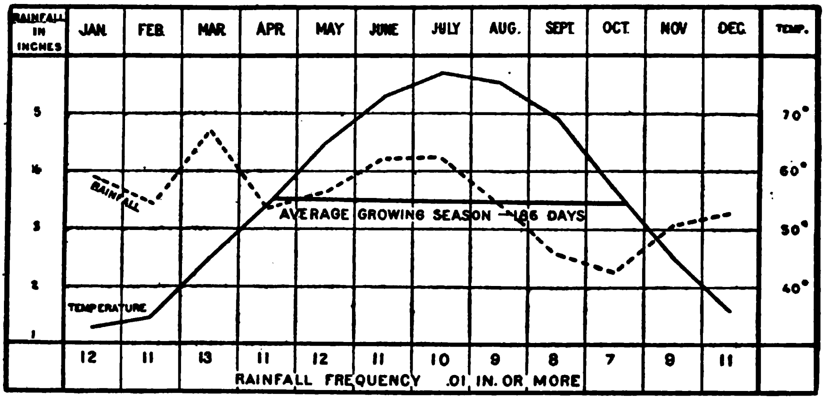

FIG. 5.—Diagram showing average climatic conditions.

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[1] See Kentucky Station Bulletin 162.

[2] See Kentucky Station Bulletin 139.

depend mostly on ponds in which the surface water collects. These are usually natural depressions on the land surface, which are tramped nearly water-tight by the hoofs of animals. Wells are not reliable in this region as a source of water supply.

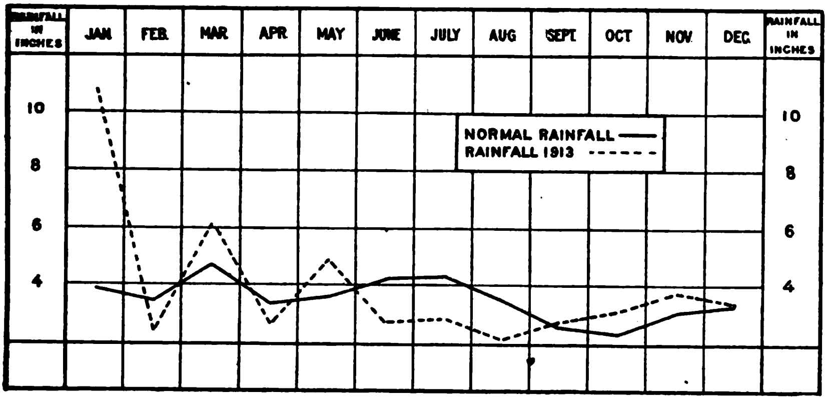

FIG. 6.—Diagram showing comparison of the actual rainfall in 1913 with normal.

## SEASONAL DISTRIBUTION OF OPERATIONS.

### CROPS.

The farm enterprises[1] found in any well-developed agricultural region are mainly those which the experience of farmers has shown to be profitable. In the process of selecting such enterprises the soil and climate are fundamental factors. Additional limiting factors are a profitable market and the availability of the right kind of labor. Still another factor not so evident as either of these is the way the various enterprises fit in with each other so as to interfere as little as possible. Each crop not only has its peculiar method of cultivation, but also its own peculiar seasons for the various operations required. Not only must a certain amount of labor be given, but this labor usually must be applied within definite seasons. Hence the organization of these enterprises must take into account economy in the distribution of labor. Even though an enterprise like tobacco, for instance, may yield a very large profit per acre, the amount that can be handled profitably on a given farm is limited not only by the amount of good tobacco soil, but by such a relation of the tobacco crop to other established enterprises as will bring about the most advantageous distribution of available labor as well as other advantages of diversity. Figures 7 and 8 show the seasonal distribution of operations required by the crops grown here, and illustrate how the operations are limited as to seasons and are distributed through the year. These diagrams are based on the practice of about 75 farmers for each crop. The black lines indicate the limits of the average of the estimates given and the dotted lines show the limits of the range of these estimates.

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[1] Definitions: Certain special terms used in this bulletin are defined below:

*Farm enterprise.*—Any crop or live-stock undertaking on the farm, such as corn, tobacco, beef cattle, or swine.

*Labor income.*—The amount the farmer receives for his labor and management besides the house rent, food, and other perquisites the farm may furnish. It is found by subtracting current expenses and interest on the total investment in the farm business from receipts.

*Animal unit.*—The equivalent of a mature farm animal, as a horse, cow, or steer; 7 sheep, 14 lambs, 5 hogs, 10 pigs, 100 poultry, 2 head of young cattle or colts are equivalent to an animal unit.

*Labor unit.*—A man-day's work of 10 hours.

*Power unit.*—One day's work of a mule, horse, or the equivalent of this work done by an engine.

*Crop index.*—A figure that measures the yield of all crops on a farm as compared with the average yield of the community. One hundred is taken as the standard measure of the farm yield of the community.

*Diversity index.*—A factor derived by reducing all the enterprises of the farm to their equivalent represented by a number of enterprises equal in value. It measures the degree of diversification of enterprises on the farm.

### LIVE STOCK.

In a manner somewhat similar to crops, live-stock enterprises require special attention at limited seasons of the year, so that in any system of general farming the operations required by them have an important influence in the organization of the farm. In figures 9 and 10 there are shown the principal operations and events occurring in the life of animals on the farm.

TABLE III.—*Labor units and power units required by various enterprises (based on average of about 75 records for each enterprise).*

| Enterprise. | Labor units.[1] | Power units.[2] | Enterprise. | Labor units.[1] | Power units.[2] |
|---|---|---|---|---|---|
| | *Per acre.* | *Per acre.* | | *Per acre.* | *Per acre.* |
| Tobacco | 38.8 | 7.7 | Meadow hay | 1.1 | 0.7 |
| Corn: | | | Cowpeas and soy beans | 1.8 | 3.0 |
| Shocked and put into crib | 4.6 | 4.4 | | | |
| Hogged down | 2.4 | 3.5 | | *Per animal unit.* | *Per animal unit.* |
| Wheat | 1.2 | 1.6 | | | |
| Rye: | | | | | |
| Thrashed | 1.3 | 2.0 | Ordinary milch cows on farm | 12.3 | 1.5 |
| Cut and fed as hay | .9 | 1.3 | Dairy cows, including marketing milk | 18.3 | 6.2 |
| Pastured | .2 | .6 | | | |
| Oats: | | | Beef cattle or general stock cattle | 1.0 | .9 |
| Thrashed | 1.2 | 1.4 | Sheep | 2.3 | .05 |
| Fed in bundles | 1.2 | 2.0 | Swine | 1.1 | .02 |

[1] Labor unit: A man-day's work of 10 hours.

[2] Power unit: One day's work by a mule, horse, or the equivalent of this work done by an engine.

## LABOR AND POWER UNITS REQUIRED.

The average number of labor units and power units required for each crop and stock enterprise is shown in Table III. These are based on about 25 records obtained in each of the counties studied as previously explained. The farmers' practice relative to the amount of work put upon the crops and live stock is quite uniform throughout the region. The variations that occur are due mainly to weather conditions and conditions of the soil rather than to the individual practice of each farmer. It is believed that the estimate of 50 to 75 farmers will give a very close average for the practice here.

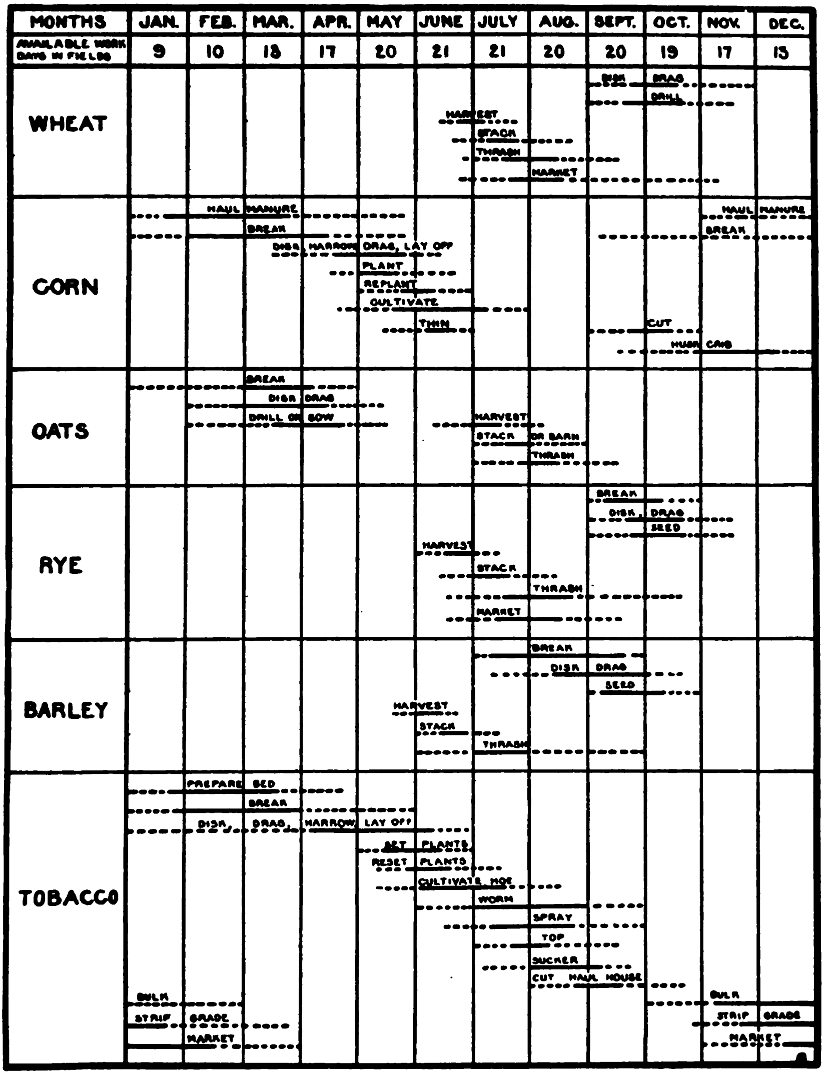

FIG. 7.—Diagram showing the seasonal distribution of labor on intertilled and cereal crops. (Black lines indicate average, dotted lines extreme range.)

The average farm of this region (about 300 acres) furnishes about 900 productive labor units and about 450 productive power units.[1]

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[1] By the terms "productive labor" and "productive power" is meant the labor or power applied directly to an enterprise which produces an income, such as a crop or a group of animals, or work which increases the value of the farm, such as building new fences, making new drains, etc. Repair work or mowing down weeds, etc., although necessary, is not regarded as "productive."

## CROP YIELDS FOR 1913.

The yields of important crops are given in Table IV. All except corn are above the figures given for the same locality in the census of 1910. The corn crop was undoubtedly cut short by the abnormally low rainfall in June, July, and August, 1913 (see rainfall chart, fig. 6.) Tobacco being a drought-resisting plant, was probably not much affected. The bluegrass pastures, however, were undoubtedly shorter than usual during this year, and as a consequence some of the farms were unable to support the normal amount of live stock through the summer.

TABLE IV.—*Average crop yields in Mason, Madison, and Scott Counties for 1913, compared with census figures of 1910.*

| Crops. | 178 records, 1913. | Census, 1910. | Crops. | 178 records, 1913. | Census, 1910. |
|---|---|---|---|---|---|
| Corn.................bushels.. | 34.5 | 38.8 | Rye.................bushels.. | 9.9 | 9 |
| Tobacco............pounds.. | 1,132 | 1,063 | Hay.....................tons.. | 1.05 | 1.01 |
| Wheat..............bushels.. | 16 | 12.9 | | | |

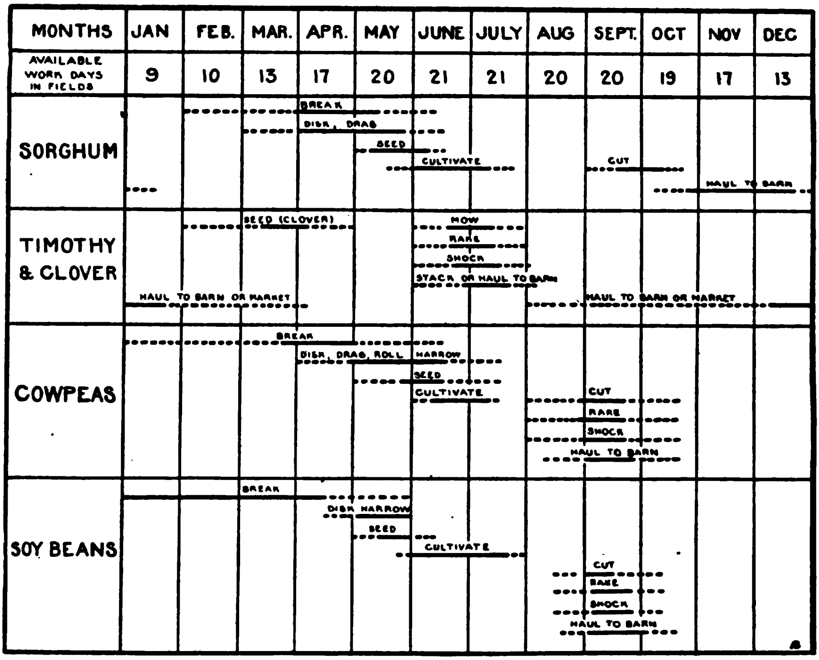

FIG. 8.—Diagram showing the seasonal distribution of labor on forage crops. (Black lines indicate average, dotted lines extreme range.)

This year was a good one for wheat, which is an early-maturing crop. The fall and winter rains, much above the normal in amount, helped to give it a good start, and a dry harvest period was very favorable. Since there was sufficient moisture to give tobacco a good start, the dry summer may have been of some advantage to that crop.

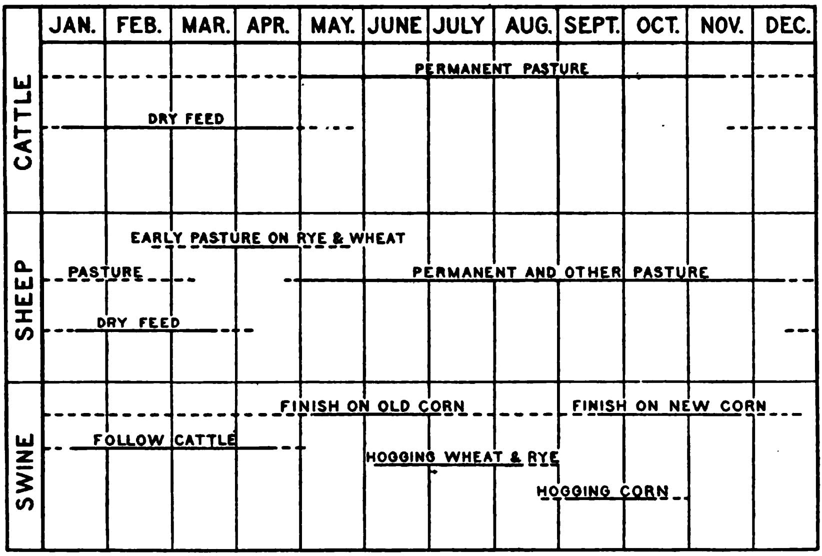

FIG. 9.—Diagram showing the seasonal feeding practice relative to cattle, sheep, and swine. (Black lines indicate average, dotted lines extreme range.)

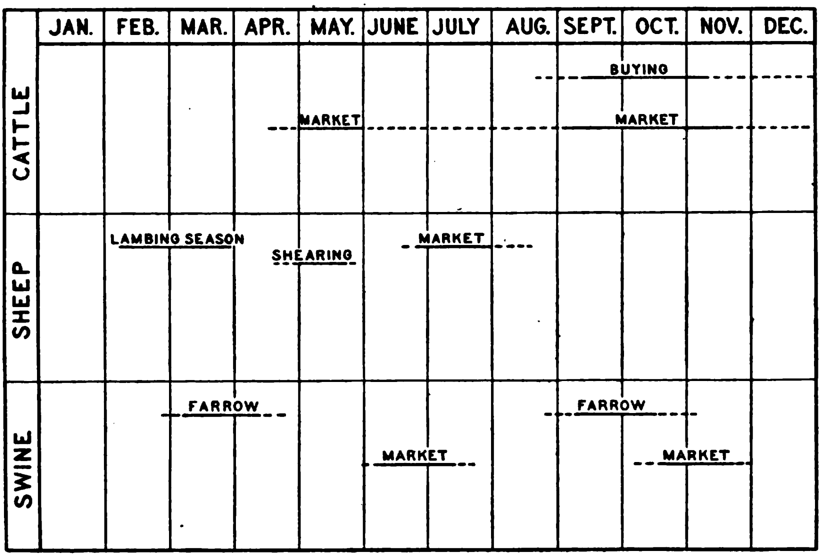

FIG. 10.—Diagram showing seasonal distribution of operations and events other than feeding relative to cattle, sheep, and swine. (Black lines indicate averages, dotted lines extreme range.)

Taking into consideration all factors, this season undoubtedly is fairly representative of an average year.

## LAND TENURE AND CROPPER LABOR.

A large majority of the farms here are operated by owners, while most of the tobacco, and, to some extent, corn and other crops, are raised by croppers. These may, however, be regarded as practically laborers, since in most cases the owner or regular tenant of the farm on which the cropper operates has general supervision. In most cases the owner or regular tenant furnishes the work stock and tools and looks after the sales. Receipts from the crops are usually divided equally between the farm operator and the cropper. The cropper as a rule lives on the farm, has the use of a cottage and small garden, and is allowed to pasture a cow or two and a horse, if he owns one. This system gives a little added independence to the laborer and enables him to support a family, the members of which can utilize much of their time to advantage by working in the tobacco fields.

TABLE V.—*Relation of tenure to capital and to rents (averages of 177 bluegrass farms).*

| Tenure. | Number of records. | Size of farm. | Total capital. | Investment in real estate. | Investment in working capital. | Land earnings per acre.[1] | 5 per cent interest on real-estate value per acre. | Rent paid by tenant per acre. |
|---|---|---|---|---|---|---|---|---|
| | | *Acres.* | | | | | | |
| Owner farms........... | 130 | 303 | $37,741 | $32,645 | $5,096 | $5.97 | $5.39 | ........ |
| Owner—additional..... | 27 | 344 | 40,056 | 33,822 | 6,234 | 4.22 | 4.92 | [2] $4.70<br>[3] 12.60 |
| Cash tenant............ | 13 | 356 | 36,377 | 31,483 | 4,894 | 5.20 | 4.42 | 4.02 |
| Share tenant........... | 7 | 192 | 27,455 | 23,950 | 3,609 | 7.62 | 6.24 | 7.33 |
| All farms......... | [4] 177 | 309 | 37,991 | 32,760 | 5,231 | 5.34 | 5.25 | 5.06 |

[1] Land earnings are the difference between value per acre of total production and total operating expenses. Total production includes the value of all crops sold, fed to live stock, and used by the family; also value of all live-stock products and net receipts from live stock sold. Operating expenses are all current expenses including value of products consumed and operator labor and management, but not interest on real-estate value.

[2] Cash.

[3] Share.

[4] One additional farm operated by a manager.

Table V shows the farms grouped on the basis of tenure. One hundred and thirty out of 177, or about 74 per cent, of the farms included in this study are owner farms. It is interesting and instructive to compare in this table the land earnings with the rental value of the land, which is here assumed to be 5 per cent on the real-estate investment. The average of all farms in the group earns but 9 cents per acre more than 5 per cent on the average estimated acre value of real estate. The average tenant pays $5.06 per acre rent, which is but 19 cents less than the interest at 5 per cent. Some farmers fail to clear as much as fair interest on the land investment; others clear much more, but the average is not far from 5 per cent on investment. If all the farmers were found to be making more than the current rate of interest on their valuation of the land the tendency would naturally be toward an increase in land values and a rise in rents. The farmers in this section have evidently valued their land approximately on the basis of its real earning capacity.

The fact that the average farmer in the group studied had left, after counting out all operating expenses, just about enough to pay interest on his land investment does not indicate that the farmer is not making money. On the other hand, it may indicate quite the opposite. In arriving at the remainder left for interest the average farmer is allowed fair wages for his services as manager and his family is allowed common wages for the work they do. In addition, the family have a home and a large percentage of their food free of money cost and a fair rate of interest on the working capital invested. In the case of a large number of farmers in the region equal comfort in the home and its surroundings and equal opportunity for outdoor recreation could not be afforded in the city except by the more wealthy. These advantages have a real value, but they evidently have not been capitalized by the farmers who gave the records.

A few farmers during the year made comparatively large profits, while a few suffered large losses, the main reasons for which will be pointed out in the following pages. The large majority, however, could live in comfort and lay aside something in the bank.

It will be noticed that cash tenants pay less rent than do those who rent on shares. There would naturally be a certain difference in favor of the cash tenant, since usually the landlord would rather rent at a lower rate for cash than for a share of the crop; but the large difference shown in the table is due principally, no doubt, to the fact that most of the share-rented land is in relatively small areas and much of it is devoted to tobacco, one-half of which is turned over to the owner. On the other hand, cash-rented land is in large areas and devoted more largely to pasture.

## IMPORTANCE OF SIZE OF FARM.

The farms vary greatly in size. The smallest farm had 35 acres, the largest 5,000. This factor more than any other seems to determine their organization, as the following analysis will show:

### RELATION OF SIZE OF FARM TO DISTRIBUTION OF RECEIPTS.

In Table VI it will be seen that the small-sized farms get most of their receipts from crops, while the large farms get most of their income from live stock. Small farms have the largest percentage of receipts from tobacco. This crop decreases in relative importance as the farms increase in size.

TABLE VI.—*Relation of size of farm to receipts from crops and live stock.*

| Range. | Number of records. | Average size. | Per cent receipts from all crops. | Per cent receipts from tobacco. | Per cent receipts from live stock. |
|---|---|---|---|---|---|
| | | *Acres.* | | | |
| 100 acres or less | 19 | 73 | 63 | 44 | 34 |
| 101 to 200 acres | 48 | 156 | 58 | 37 | 41 |
| 201 to 300 acres | 51 | 251 | 56 | 34 | 43 |
| 301 to 500 acres | 33 | 382 | 50 | 30 | 49 |
| 501 to 700 acres | 15 | 571 | 48 | 25 | 50 |
| Over 700 acres | 12 | 1,020 | 43 | 19 | 55 |
| All farms | 178 | 310 | 55 | 34 | 44 |

## RELATION OF SIZE OF FARM TO DISTRIBUTION OF CROPS.

The percentage area in crops decreases and the percentage area in pasture increases as the size of the farm becomes larger, as shown in Table VII. This relative variation is consistent with the facts brought out in Table VI, since the increase in percentage area in pasture would mean more live stock and thus a higher percentage of receipts from this source. The percentage area in tobacco is largest on the small farms. The small farmer increases the size of his business by this means. More labor is thus employed per acre and a greater income realized. In the case of other crops the size of the farm apparently affects the distribution but little.

TABLE VII.—*Percentage distribution of farm area in various crops (farms grouped on the basis of size).*

| Size of farm. | Number of records. | Per cent of farm area in crops. | Per cent of farm area in pasture. | Per cent of farm area in corn. | Per cent of farm area in tobacco. | Per cent of farm area in wheat. | Per cent of farm area in other cereals. | Per cent of farm area in hay and mixed forage. |
|---|---|---|---|---|---|---|---|---|
| 100 acres or less | 19 | 56 | 39 | 41 | 15 | 13 | 13 | 14 |
| 101 to 200 acres | 48 | 58 | 41 | 32 | 11 | 26 | 10 | 19 |
| 201 to 300 acres | 51 | 42 | 54 | 36 | 10 | 23 | 13 | 17 |
| 301 to 500 acres | 33 | 44 | 53 | 35 | 9 | 23 | 16 | 15 |
| 501 to 700 acres | 15 | 46 | 53 | 39 | 8 | 23 | 16 | 13 |
| Over 700 acres | 12 | 35 | 59 | 40 | 7 | 23 | 14 | 14 |
| All farms | 178 | 47.9 | 48.9 | 36 | 9 | 24 | 14 | 15 |

## RELATION OF SIZE OF FARM TO DISTRIBUTION OF LIVE STOCK.

Cattle predominate among the live-stock enterprises, an average of 60 per cent being of this class, and about this percentage distribution is maintained on farms of all sizes, excepting farms over 700 acres in size, which show 75 per cent of animal units in cattle. These facts are shown in Table VIII. Steers predominate on the larger farms, while a larger percentage of cows and young stock are kept on the smaller farms. The distribution of other kinds of animals is not influenced in any important way by the size of the farm. The fact, however, that all farms have about the same amount of poultry makes the percentage amount kept on small farms much larger than on large farms.

TABLE VIII.—*Percentage distribution of different classes of animal units.*

| Size of farm. | Number of records. | Per cent cows and young stock. | Per cent steers. | Per cent total cattle. | Per cent horses and mules. | Per cent sheep. | Per cent swine. | Per cent fowls. |
|---|---|---|---|---|---|---|---|---|
| 100 acres or less | 19 | 24 | 39 | 65 | 7 | 3 | 19 | 6 |
| 101 to 200 acres | 48 | 26 | 26 | 52 | 6 | 10 | 26 | 6 |
| 201 to 300 acres | 51 | 22 | 35 | 56 | 5 | 15 | 20 | 4 |
| 301 to 500 acres | 33 | 14 | 48 | 61 | 6 | 11 | 20 | 2 |
| 501 to 700 acres | 15 | 12 | 50 | 62 | 6 | 12 | 18 | 2 |
| Over 700 acres | 12 | 11 | 64 | 74 | 2 | 6 | 17 | 1 |
| Total averages | 178 | 16 | 44 | 60 | 5 | 11 | 20 | 4 |

## RELATION OF SIZE OF FARM TO CAPITAL AND INCOME.

Table IX shows the amount of capital invested on farms of various sizes, and shows also the farm income and labor income. The farm income increases with the size. The labor income similarly increases with the size of the farm. There is an exception in the group of farms of from 301 to 500 acres. There falls into this group a large number of farms classified as "general mixed farms" (see p. 18), which stand between the types specializing in either tobacco or live stock, and which are the least efficient of all types. (See also Table X.)

TABLE IX.—*Capital and incomes on farms of different sizes.*

| Size of farm. | Number of records. | Average size of farm. | Total capital invested. | Investment in real estate. | Investment in working capital. | Farm income. | Labor income. |
|---|---|---|---|---|---|---|---|
| | | *Acres.* | | | | | |
| Less than 100 acres | 19 | 73 | $12,502 | $10,338 | $2,164 | $1,083 | $473 |
| 101 to 200 acres | 48 | 156 | 21,241 | 18,203 | 3,038 | 1,537 | 518 |
| 201 to 300 acres | 51 | 251 | 30,697 | 26,548 | 4,149 | 2,015 | 595 |
| 301 to 500 acres | 33 | 382 | 48,618 | 41,856 | 6,762 | 2,554 | 299 |
| 501 to 700 acres | 15 | 571 | 75,836 | 66,612 | 9,224 | 4,809 | 1,542 |
| Over 700 acres | 12 | 1,020 | 97,009 | 82,952 | 14,057 | 6,504 | 2,130 |
| All farms | 178 | 310 | 37,793 | 32,585 | 5,208 | 2,419 | 686 |

TABLE X.—*Relation of size of farm to utilization of labor, power, and machinery.*

| Size of farm. | Number of farms. | Per cent of available time utilized by man labor. | Per cent of available time utilized by work stock. | Cost of work stock per power unit. | Cost of machinery per power unit. |
|---|---|---|---|---|---|
| Less than 100 acres | 19 | 78 | 27 | $2.68 | $0.46 |
| 100 to 200 acres | 48 | 95 | 28 | 1.84 | .35 |
| 201 to 300 acres | 51 | 87 | 33 | 1.54 | .21 |
| 301 to 500 acres | 33 | 84 | 33 | 1.78 | .17 |
| 501 to 700 acres | 15 | 80 | 37 | 1.36 | .13 |
| Over 700 acres | 12 | 80 | 48 | 1.18 | .07 |

TABLE XI.—*Relation of size of business (measured by operating expenses) to labor income.*

| Operating expenses. | Number of records. | Farm area. | Average operating expenses. | Value of total production. | Labor income. |
|---|---|---|---|---|---|
| | | *Acres.* | | | |
| $3,000 or less | 48 | 143 | $2,236 | $2,955 | $323 |
| $3,001 to $5,000 | 63 | 234 | 3,785 | 4,932 | 548 |
| $5,001 to $7,000 | 30 | 320 | 5,787 | 7,651 | 786 |
| Over $7,000 | 37 | 648 | 10,022 | 13,461 | 1,393 |
| All farms | 178 | 310 | 5,001 | 6,630 | 686 |

### RELATION OF SIZE OF BUSINESS TO LABOR INCOME.

The size of the farm in this region is an unreliable measure of the size of the farm business, owing to the fact that many farms with a comparatively small arceage have a larger business than is conducted on farms much larger in area. The operating expenses, however, give an approximately accurate measure of the size of business. In Table XI, showing the relation of the size of business to labor income, the farms are sorted into groups on the basis of operating expenses. It will be observed that the labor income increases with the size of business.

### TYPES OF FARMS.

Table XII shows the farms grouped on the basis of type.[1] Judging from the mere outward appearance of all the farms studied, except the 10 dairy farms, there would seem to be one general type of farm. All raise about the same crops and handle about the same classes of live stock. The differences lie in the relative percentage of receipts from live stock, tobacco, and other crops, which affects the organization and thus distinguishes specific types. The stock farms require less labor in proportion to size of business and to size of farm than farms of the tobacco or the dairy type. Stock farming, to be profitable, requires relatively a large amount of capital invested in live stock and less per acre in land. Tobacco, on the other hand, is a highly specialized enterprise, requiring a large amount of labor per acre of crops and yielding much greater returns per acre than live stock. (See Table XII.)

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[1] The tobacco type includes all farms that have 50 per cent or more of their receipts from tobacco, with not over 30 per cent from any one other source.

Tobacco-stock farms have 75 per cent or more of their receipts from tobacco and live stock combined, the income from neither being below 30 per cent.

The general mixed type includes all farms that do not fall into any of the other types.

Stock farms with tobacco have 50 per cent or more of their receipts from live stock, with not over 30 per cent from any one other source.

Stock farms with no tobacco have 50 per cent or more of their receipts from live stock, but grow no tobacco.

Dairy farms have 50 per cent or more of their receipts from dairy products.

TABLE XII.—*Showing the grouping of farms on the basis of type, the size of farm, the distribution of capital, and the labor income of each.*

| Type of farm. | Number of records. | Average size of farm. | Total capital per farm. | Real estate per farm. | Working capital per farm. | Labor income per farm. |
|---|---|---|---|---|---|---|
| | | *Acres.* | | | | |
| Tobacco | 31 | 171 | $24,693 | $21,729 | $2,964 | $503 |
| Tobacco stock | 61 | 300 | 34,841 | 30,069 | 4,772 | 778 |
| General mixed | 36 | 328 | 43,198 | 38,540 | 4,658 | 471 |
| Stock with tobacco | 31 | 367 | 45,613 | 38,468 | 7,145 | 1,202 |
| Stock with no tobacco | 18 | 457 | 44,148 | 35,603 | 8,545 | 994 |
| Dairy | 10 | 163 | 22,494 | 17,732 | 4,762 | 1,931 |
| All farms | 187 | 310 | 37,793 | 32,585 | 5,208 | 686 |

Tobacco, of course, occupies relatively but a small part of the area even of the tobacco farms, while pasture occupies from one-third to more than one-half of the farm area on the stock farms. (See figs. 11 and 12.)

## RELATION OF TYPE OF FARM TO EFFICIENCY.

In Table XIII an important point to be observed is the relation between land earnings and 5 per cent interest on land values, which may be regarded as rent. The average of each type, except the general mixed type, is making something above operating expenses. The average of all farms shows almost a balance between land earnings and rent. The dairy type shows the highest profits and highest efficiency. This type is limited in its development, however, since it depends for marketing its product on the local towns and cities. The type not thus limited in its development which shows the highest efficiency is the stock-with-tobacco type. With the exception of the dairy farms, this type had the highest percentage of farms making over $500 labor income. The general mixed farms had the lowest efficiency and the lowest percentage of farms making this amount of labor income.

TABLE XIII.—*Relation of type of farm to efficiency.*

| Type of farm. | Number of records. | Value of total production per acre. | Operating expense per acre. | Land earnings per acre. | 5 per cent interest on land value. | Per cent of farms with over $500 labor income. |
|---|---|---|---|---|---|---|
| Tobacco | 31 | $28.40 | $22.50 | $5.90 | $6.35 | 50 |
| Tobacco stock | 61 | 24.80 | 19.50 | 5.30 | 5.00 | 50 |
| General mixed | 36 | 22.14 | 17.11 | 5.03 | 5.90 | 36 |
| Stock with tobacco | 31 | 28.20 | 19.70 | 8.50 | 5.25 | 58 |
| Stock with no tobacco | 18 | 16.97 | 12.60 | 4.37 | 3.90 | 55 |
| Dairy | 10 | 47.88 | 28.82 | 19.06 | 5.45 | 70 |
| Average of all | 187 | 21.40 | 16.06 | 5.34 | 5.25 | 49 |

## RELATION OF TYPE OF FARM TO UTILIZATION OF PASTURE.

According to results shown in Table XIV, the dairy type of farm would seem to utilize pasture most efficiently. This, however, is not necessarily true. The apparent efficiency of that type may be explained by the fact that dairy farms depend on silage and concentrated feeds in addition to bluegrass pasture, while the other types of farms mostly "rough" the young cattle and steers through the winter and depend entirely on bluegrass to put on growth and fat during the summer. This system would necessarily require more acres of pasture per animal unit than the dairy system. It will be observed, however, that the stock-with-tobacco type utilizes pasture area more efficiently than any of the other common types.

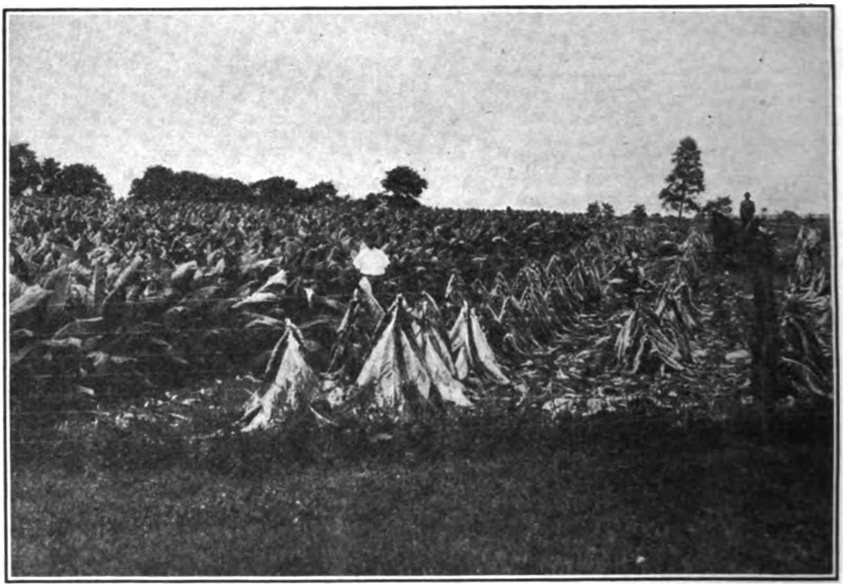

FIG. 11.—Typical tobacco field. Even on the tobacco farms tobacco occupies a relatively small part of the farm area.

TABLE XIV.—*Relation of type of farming to utilization of pasture area.*

| Type of farm. | Number of records. | Crop index. | Farm acres per animal unit. | Pasture acres per animal unit. |
|---|---|---|---|---|
| Tobacco | 31 | 93 | 10 | 4.3 |
| Tobacco, stock | 61 | 96 | 6 | 3.3 |
| General mixed | 36 | 99 | 8 | 3.7 |
| Stock with tobacco | 31 | 102 | 5 | 2.7 |
| Stock with no tobacco | 18 | 113 | 6 | 3.6 |
| Dairy | 10 | 99 | 3 | 1.8 |

The renting value of land, as shown in Table XIII, would indicate that with the exception of the stock-with-no-tobacco type the land should be similar in quality. The stock-with-no-tobacco type of farm is the largest in area and usually much of the pasture land is hilly and of poor quality, hence would not be expected to utilize pasture area as efficiently as could be done on lands better in quality and higher in price. The tobacco farms and the "general mixed" farms would seem to have higher quality of land, yet there is comparatively low efficiency in the utilization of pasture area. These types specialize on crops and apparently have neglected to utilize fully pasture land.

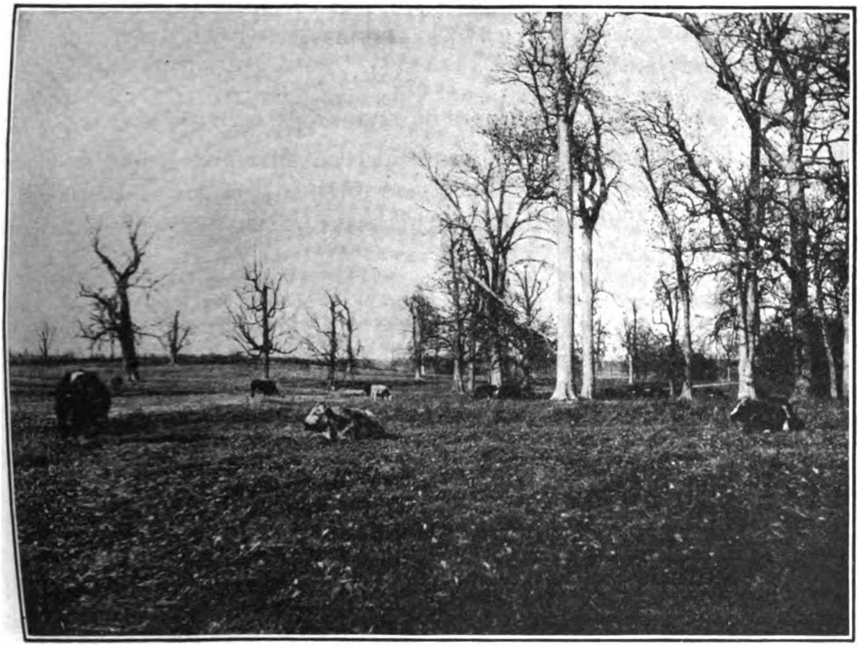

FIG. 12.—Typical bluegrass pasture. Bluegrass occupies from one-third to more than one-half of the farm area on the stock farms.

## RELATION OF TYPE OF FARM TO CROP YIELD.

Table XV shows for the year 1913 the yield of various crops in the region.

TABLE XV.—*Average yield of crops on farms of various types.*

| Type of farm. | Number of records. | Yield of corn. | Yield of tobacco. | Yield of wheat. | Yield of rye. | Yield of oat hay. | Yield of hay. |
|---|---|---|---|---|---|---|---|
| | | *Bushels.* | *Pounds.* | *Bushels.* | *Bushels.* | *Tons.* | *Tons.* |
| Tobacco | 31 | 30.5 | 1,196 | 17.7 | 9.1 | 0.67 | 1.09 |
| Tobacco stock | 61 | 33.1 | 1,112 | 14.5 | 10.0 | .94 | 1.06 |
| General mixed | 36 | 30.6 | 1,093 | 17.0 | 10.4 | 1.26 | 1.12 |
| Stock with tobacco | 31 | 36.6 | 1,192 | 15.0 | 10.3 | 1.40 | .93 |
| Stock with no tobacco | 18 | 44.2 | .......... | 14.5 | 7.14 | .88 | .85 |
| Dairy | 10 | 29.6 | 1,054 | 19.6 | .......... | .......... | 1.10 |
| All farms | 187 | 34.5 | 1,132 | 16.0 | 9.9 | 1.06 | 1.05 |

As is pointed out in Table IV, page 12, the corn crop was cut short by drought. The corn crop is important in proportion to the amount of live stock kept. The stock-with-tobacco and the distinctly stock types show higher yields than other common types. The fact that the dairy farms show a low yield of corn can not be explained unless by the fact that the records were few. The crop index would show that the productiveness of the farm increases with increasing importance of live stock and decreases with increasing importance of tobacco.

### IMPORTANCE OF RIGHT AMOUNT OF LIVE STOCK ON THE FARM.

The fact that about half of the area of these farms is kept in bluegrass pastures makes the full utilization of such pasture a matter of great importance. The relation that this bears to efficiency is shown in Tables XVI and XVII.

TABLE XVI.—*Relation of utilization of pasture area to efficiency.*

| Pasture per animal unit. | Number of records. | Average number acres of pasture per animal unit. | Average farm acres per animal unit. | Feed cost per animal unit.[1] | Labor income. |
|---|---|---|---|---|---|
| 2 acres or less | 42 | 1.4 | 4 | $31 | $1,114 |
| 2.1 to 3 acres | 49 | 2.5 | 5 | 37 | 960 |
| 3.1 to 4 acres | 38 | 3.6 | 9 | 38 | 711 |
| 4.1 to 5 acres | 17 | 4.4 | 8 | 45 | 311 |
| Over 5 acres | 25 | 7.0 | 10 | 58 | −93 |

[1] The feed cost here calculated included the value of pasture, which ranged from $2.25 to $5 per acre and averaged about $3.50 per acre.

TABLE XVII.—*Relation of farm acres per animal unit to crop index and labor income on 121 farms similar in type.*

| Farm acres per animal unit. | Number of records. | Average acres per animal unit. | Size of farms. | Value of land per acre. | Crop index. | Labor income. |
|---|---|---|---|---|---|---|
| | | | *Acres.* | | | |
| Less than 4 acres | 17 | 3.1 | 219 | $138 | 115 | $1,381 |
| 4 to 5.4 acres | 36 | 4.8 | 294 | 111 | 108 | 1,006 |
| 5.5 to 6.9 acres | 28 | 6.1 | 303 | 106 | 100 | 393 |
| 7 to 8.9 acres | 26 | 7.6 | 305 | 115 | 98 | 256 |
| Over 9 acres | 20 | 12.0 | 354 | 109 | 100 | −214 |

In the first of these tables is shown the relation of acres of pasture per animal unit to labor income, in the other the relation of farm acres per animal unit to these factors. The group of farms most heavily stocked has also the highest priced land and shows the highest crop index. This fact may explain why this particular group was able to stock most heavily. The other groups, however, do not show any marked difference in respect to the quality of the land, as shown by the values given and the crop index, and it would naturally be expected that each would show about the same efficiency in the utilization of pasture area. The failure to maintain efficiency in this regard has evidently been an important factor in lowering general efficiency and thus labor incomes. The farms that have labor incomes below $500 almost invariably show a poor utilization of pasture area.

It will be observed in Table XVI that the group of farms which furnishes over 5 acres of pasture for each animal unit have nearly twice the feed cost per farm as the group that furnished but 2 acres or less. This increased feed cost would necessarily follow where the acreage used by each animal unit increased with no decrease in the cost per acre of pasture. The group of farms showing lowest efficiency in the utilization of pasture area was only slightly lower in general quality than the preceding group and about the same quality as the third group, as indicated by the value of the land.

## CROP YIELD AN IMPORTANT FACTOR IN EFFICIENCY.

A factor of prime importance to profitable farming on these farms is the crop yields. In Table XVIII is shown the relation of crop yield to labor income and farm efficiency. The yield of all crops is reduced to a crop index, as explained on page 22, 100 representing the average yield for all the farms giving records. Labor income increases directly as the average index of yield of the different groups increases. It is, of course, possible to secure high yields of crops at too great expense, but there is no indication that any of the farms studied here made any error on this point. Practically no commercial fertilizer was used. The common method of utilizing manure from animals would generally be regarded as wasteful.

TABLE XVIII.—*Relation of crop yield to labor income.*

| Crop index. | Number of records. | Size of farm. | Labor income. |
|---|---|---|---|
| | | *Acres.* | |
| 90 or less | 35 | 303 | $217 |
| 91 to 100 | 37 | 297 | 519 |
| 101 to 110 | 47 | 273 | 701 |
| 111 to 120 | 30 | 362 | 1,080 |
| Over 120 | 29 | 341 | 1,103 |

About 65 records were taken on methods of keeping up fertility. These showed that the average farmer hauled to the fields about 14 per cent of the manure produced on his farm. In this section, however, feed for live stock is generally hauled to the pastures and scattered about on places needing manure. In this way a great deal of manure is returned to the soil. It is estimated that about 50 per cent of the manure produced on these farms is utilized in keeping up soil fertility. The rest is wasted.

## RELATION OF DIVERSITY TO PROFITABLE FARMING.

The principal advantages which diversity may secure are: (1) The adaptation of enterprises to the physical conditions of the farm as in cases where parts of the area are hilly or stony or where there are differences in soil; (2) the maintenance of soil fertility, as effected by having a legume in the rotation, or a blue-grass sod; (3) the profitable distribution of labor (other things equal, the system that utilizes available labor best has the advantage); (4) adaptation to market conditions. Market prices fluctuate often to the extent of causing serious loss where attention is centered on any one enterprise. Diversity steadies the income of the farm and makes it more dependable.

TABLE XIX.—*Relation of type of farm to diversity.*

| Type of farm. | Number of records. | Per cent receipts from crops. | Per cent receipts from livestock. | Per cent receipts from tobacco. | Diversity index. |
|---|---|---|---|---|---|
| Tobacco | 31 | 80 | 19 | 65 | 2.3 |
| Tobacco stock | 61 | 55 | 44 | 43 | 3.4 |
| General mixed | 36 | 68 | 31 | 27 | 4.6 |
| Stock with tobacco | 31 | 37 | 59 | 21 | 4.1 |
| Stock with no tobacco | 18 | 18.3 | 81 | .......... | 2.8 |
| Dairy | 10 | 12 | 87 | 7 | 2.0 |

Diversity is closely related to the size of farm. In the bluegrass region it would not be profitable even on the larger and cheaper farms to have all of the farm area in bluegrass, neither would it be profitable on small, high-priced farms to cultivate the entire area in tobacco. Through long experience the farmers have arrived at a distribution which, on the whole, has proved profitable under the conditions prevailing. (See Table VII.)

The degree of diversity varies on different types of farms, as shown in Table XIX. Here it will be observed that the tobacco type and the stock type have the lowest diversity, while the intermediate types have the highest diversity. The tobacco and the stock type each emphasizes a single enterprise. The typical tobacco farm is relatively small in size, and in order to have a business of adequate magnitude the percentage of crop area in tobacco must be relatively large and the pasture area relatively small. A small area of pasture tends to decrease the receipts from stock. On the other hand, the distinctly stock farm is relatively large in size, has a poorer quality of soil, and is cheaper in price per acre than farms of other types. Usually the topography is quite rolling and sometimes it is stony, a condition which is a handicap in tillage. In such cases it is more advantageous to leave a large proportion of the area in pasture and to till only the more level and more productive land.

Table XX shows the diversity that corresponds to highest efficiency on each type of farm. It is evident from this table that there could be no general increase in efficiency through increase in diversity, since the diversity which gives highest efficiency is about equal to the average for each type. There is as much liability to lose through overdiversity as through underdiversity. The average farm of each type has no doubt about the diversity it should have.

**Table XX.**—*Showing the diversity index that corresponds to maximum efficiency on various types of farms.*

| Type. | Number of records. | Size of farm. | Diversity index corresponding to highest efficiency. | Average diversity |
|---|---|---|---|---|
| | | *Acres.* | | |
| Tobacco | 31 | 174 | 2.4 | 2.3 |
| Tobacco stock | 61 | 344 | 4.6 | 3.4 |
| General mixed | 36 | 256 | 3.8 | 4.6 |
| Stock with tobacco | 31 | 316 | 3.6 | 4.1 |
| Stock with no tobacco | 18 | 683 | 2.0 | 2.8 |

## COST OF PRODUCTION.

In Table XXI are shown the average unit value and cost of production for several important enterprises. In arriving at these figures every item of expense, including the cost of operator's labor and management and of rent has been counted. Values have been determined by current market prices.

**Table XXI.**—*Unit cost and value for several important enterprises on the different types of farms for the year 1913.*

| Type of farm. | Number of records. | Corn, per bushel. | | Tobacco, per pound. | | Wheat, per bushel. | | Rye, per bushel. | | Meadow hay, per ton. | | Productive live stock, animal unit basis. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cost. | Value. | Cost. | Value. | Cost. | Value. | Cost. | Value. | Cost. | Value. | Cost. | Value |
| Tobacco | 31 | $0.76 | $0.76 | $0.113 | $0.118 | $0.73 | $0.98 | $1.33 | $0.84 | $16.67 | $16.06 | $48.51 | $42.40 |
| Tobacco stock | 61 | .71 | .76 | .123 | .119 | .88 | .98 | 1.04 | .84 | 16.00 | 16.06 | 39.75 | 47.66 |
| General mixed | 36 | .73 | .76 | .130 | .116 | .75 | .98 | 1.01 | .84 | 15.27 | 16.06 | 47.92 | 47.73 |
| Stock with tobacco | 31 | .65 | .76 | .120 | .117 | .84 | .98 | 1.01 | .84 | 18.94 | 16.06 | 44.86 | 54.93 |
| Stock with no tobacco | 18 | .64 | .76 | ..... | ..... | .98 | .98 | 1.22 | .84 | 22.50 | 16.06 | 41.96 | 53.49 |
| Dairy | 10 | .81 | .76 | .127 | .104 | .68 | .98 | ..... | .84 | 18.16 | 16.06 | 66.24 | 100.88 |
| Av. of all | 187 | .68 | .76 | .127 | .118 | .80 | .98 | 1.05 | .84 | 17.75 | 16.06 | 44.41 | 52.55 |

The enterprises are usually so dependent on each other, and their place in the farm organization so related to the utilization of labor and to other factors, that the distribution of costs is a difficult matter. In fact, no system has as yet been devised which can be said to make this distribution in any but an approximately correct manner.[1] The reader must keep in mind the fact that the figures given in the table apply only to the average farm of each type, and that while some farmers are selling the crop at below the cost of production, others get much more than the cost. Farming may be said to be profitable when the operating costs, rightly interpreted, about equal the returns, since the costs include pay for the farmer's labor and services as manager, allowance for family labor, current rate of interest on working capital, and rent for his land, if he is an owner. Then, too, he is insured employment for himself and family, and a fair rate of interest on a secure investment. Also, if the farm is rightly organized and its fertility well maintained, it will tend to increase in value. A comparison of the cost and value per pound of tobacco on the average of 187 farms illustrates these facts. Included in the cost of one acre of this crop are $92.69 for labor and management, $11.36 for horse labor, $1.05 for fertilizer, $2.38 for miscellaneous costs, and $34.73 for rent. This value for rent is the average estimated cash amount which the landlord should get for the use of the land for tobacco. The average cost per pound, on this basis, is shown to be slightly above the average price received. The crop, nevertheless, may be regarded as a profitable one for the reason that it employs labor almost continuously throughout the year and it may be depended on for a reliable income. It gives the owner a high rent for his land rather than the relatively low rent which he would have to accept for its use for other crops.

The values of all crop enterprises, except wheat and tobacco, are based on prices of imported products. Oats, corn, hay, and rye are consumed by stock, and during parts of the year these products are shipped in to supply deficiency. The cost of hay and of all other products includes the hauling to market.

Live stock does not seem to be profitable on the tobacco or the mixed type of farms. These types emphasize crops, especially tobacco, and evidently neglect live stock.

In general it is the aim of farmers in this region to raise just enough hay to supply the needs for live stock. It is not a profitable crop to market. On the basis of present yields it would probably not pay to market corn.

---

[1] The costs as shown in Table XXI were distributed to each enterprise in the following manner:

Labor costs were distributed in proportion to the number of labor units required by each enterprise (see Table IV). "Cash to run farm" was distributed in the same way.

Power costs were distributed in proportion to the power units required by each enterprise (see Table IV). Machinery costs were distributed in the same way.

Rent charges included interest on fixed capital, such as buildings, fences, etc. The renting value of land on the average farm was about $5 per acre. Land used for general crops, such as corn, wheat, rye, pasture, including bluegrass pasture, was shown to have a uniform renting value on each farm, ranging from $2.25 to $6 per acre. The average rent for pasture land was $3.50 per acre; for general crop land, about $3.60. Renting value given for tobacco land ranged between $25 and $75 per acre, the average being about $35.

Live stock was charged for feed, including pasture, at farm prices. Six dollars and fifty cents was credited to each animal unit for manure and the same amount charged to field crops in proportion to acreage. Six per cent interest was charged on investment in live stock and an allowance made for depreciation.

The growing popularity of the practice of "hogging-down" wheat illustrates how the farmer aims at the organization of enterprises in such a way as to obtain maximum profit. If hogs can be turned into the wheat field there is saved the harvesting, thrashing, and hauling of wheat to market. The labor saved may be utilized in other ways. Then, if the gains on hogs are adequate, it is often possible to get more out of the wheat crop than by harvesting and thrashing it, as is usually done. Winter cover crops, such as wheat and rye, may be judiciously pastured in fall, winter, or spring, and may thus add to the profits of the farm. Bluegrass pastures are often stripped for the seed, and in this way profits from pasture land are increased. (See fig. 13.) It was noticeable that the most successful group of farms had a relatively large percentage of such forage crops as sorghums, peas, and beans, which were substituted for a part of the area devoted to hay, which is shown to be an unprofitable crop.

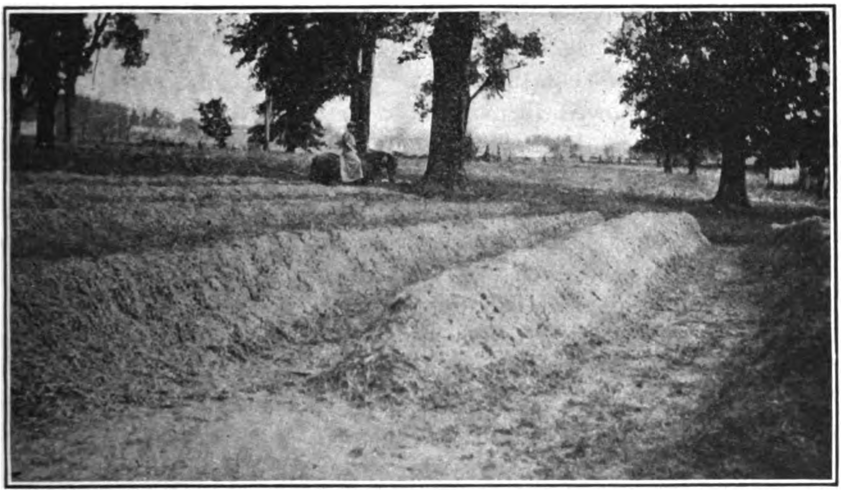

FIG. 13.—Bluegrass seed in process of curing.

On the whole, the average farmer of the region seems to be raising the various crops in about the right proportion for a profitable business.

## THE PRIME FACTORS IN PROFITABLE FARMING.

The factors that stand out as important in profitable farming in the localities surveyed are (1) size of business, (2) utilization of pasture area, (3) crop yields, (4) type of farm.

Underlying and closely related to size of business and type of farm are the factors of diversity, utilization of man and horse labor, distribution of crops and live stock from the standpoint of the advantageous utilization of field crops and pasture area, and the distribution of capital.

The farmer may increase the size of business either by buying or renting more land or by increasing the acreage of tobacco, an intensive crop. There are many farms 300 to 500 acres in size which do not show as large a business as many other farms 100 to 200 acres in size which have a relatively large percentage of area in tobacco and a relatively small percentage of area in bluegrass. The tobacco crop furnishes work for a large number of laborers and the returns per acre are correspondingly large.

The type of farm that does not seem to pay here is the general mixed type. Only 34 per cent of the farms of this type could be counted as distinctly successful, while the stock-with-tobacco type had about 58 per cent successful. The dairy type, of which there were only 10, showed 70 per cent successful, with a higher average labor income and higher efficiency than any other type. Of the other three types, about 50 per cent of the farms were successful.

The general mixed type is evidently organized on the wrong basis to be profitable. It has about the same proportion of its receipts from tobacco as the stock-with-tobacco type, but the percentage area in tobacco is very much smaller, only about 4.4 per cent, while the stock-with-tobacco type has an average of about 8 per cent of its area in tobacco. With the exception of tobacco, there seems to have been a failure to dispose of the crops raised, either by marketing them profitably or by utilizing them to advantage through live stock. Many with large farms and large capital seem to have been satisfied with bare interest on their investment, which was adequate for a comfortable living. These men made no effort to make the farm a business success. The tobacco area and much of the area of other crops on such farms was in most cases cultivated by cropper labor, which relieves the owner of much responsibility.

Profitable farming here hinges primarily upon keeping a proper balance between field crops and bluegrass, which is especially adapted to the soil and is a great factor in keeping up its fertility and putting it into a favorable condition for other crops, especially tobacco.

The soil of the bluegrass region is a heavy clay loam with a sticky clay subsoil. It should not be worked when in a wet condition, and during the naturally dry summers and fall it is difficult to plow. To emphasize field-crop farming it would be necessary to plant and work the soil more or less during the whole of the growing season. In the areas of the black loamy soils of the Middle West this usually can be done with little difficulty, but in this region the nature of the soil would be a serious handicap in such a practice and would put the district at an economic disadvantage if it were not that it is so well adapted to a crop like bluegrass (which loosens up a heavy clay soil) and to an intensive crop like tobacco, which yields a comparatively large income per acre.

The hilly, less productive, and cheaper lands can be organized more profitably as distinctly stock farms, with little or no tobacco. As a rule, however, the farmer must raise some tobacco to meet the requirements of labor.

The farmer who can command but a small area of land should, in order to make his farm most profitable, specialize in tobacco or, where market conditions permit, in dairying. On farms of from 260 to 360 acres in size the best results can be obtained by organizing on the basis of the stock-with-tobacco type, which emphasizes live stock but cultivates an area in tobacco large enough to utilize labor resources to advantage and to secure the advantage of diversity.

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# UNITED STATES DEPARTMENT OF AGRICULTURE

## BULLETIN No. 483

Contribution from the Bureau of Crop Estimates
LEON M. ESTABROOK, Chief

Washington, D. C. ▼ February 14, 1917

# STATISTICS OF FRUITS IN PRINCIPAL COUNTRIES

## PRODUCTION, EXPORTS, AND IMPORTS FOR THE UNITED STATES AND FOREIGN COUNTRIES

By

H. D. RUDDIMAN, Division of Crop Records

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## INTRODUCTION.

The purpose of this bulletin is to present in a concise form statistics of fruit and fruit products, including production and trade for the principal producing, exporting, and consuming countries. The figures used have been taken from official sources, usually from publications of the countries treated. Data concerning commerce in fruits are as a rule fairly complete, but those relating to production if not entirely lacking are in many instances either fragmentary or limited to census years.

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Note.—This bulletin contains a brief survey of the fruit industry in principal countries. While intended for general distribution to the public it is of especial interest to fruit growers and dealers.

# NORTH AMERICA.

## UNITED STATES.

### PRODUCTION OF FRUITS.

The total value of all fruits produced in the United States in 1909, according to the Thirteenth Census, was $218,000,000, which was equivalent to about one-third the value of the wheat crop of that year. Deciduous tree fruits furnished 65 per cent of the total fruit value, small fruits 14 per cent, citrus fruits 10 per cent, grapes 10 per cent, and tropical and subtropical, other than citrus, 1 per cent.

Fifty-nine per cent of the value of deciduous tree fruits was derived from apples, 60 per cent of the small fruits from strawberries, 77 per cent of the citrus fruits from oranges, and 97 per cent of the tropical and subtropical fruits, other than citrus fruits, from figs, pineapples, and olives.

The production of deciduous tree fruits, small fruits, and grapes was widely distributed. In the case of citrus fruits and other tropical and subtropical fruits, however, the production was confined chiefly to California and Florida.

TABLE 1.—*Fruit crops of the United States, 1909.*

(Thirteenth Census.)

| Crop. | Trees of bearing age, 1910. | Production, 1909. | Value, 1909. |
|---|---|---|---|
| Deciduous tree fruits: | *Number.* | *Bushels.* | *Dollars.* |
| Apples | 151,322,840 | 146,122,318 | 83,231,492 |
| Peaches and nectarines | 94,506,657 | 35,470,276 | 28,781,078 |
| Pears | 15,171,524 | 8,840,733 | 7,910,600 |
| Plums and prunes | 23,445,009 | 15,480,170 | 10,299,495 |
| Cherries | 11,822,044 | 4,126,099 | 7,231,160 |
| Apricots | 3,669,714 | 4,150,263 | 2,884,119 |
| Quinces | 1,154,399 | 428,672 | 517,243 |
| All other | 25,090 | 65,164 | 12,160 |
| Total deciduous tree fruits | 301,117,277 | 214,683,695 | 140,867,347 |
| Tropical and subtropical fruits: | | | |
| Citrus— | | *Boxes.* | |
| Oranges | 9,737,927 | 19,487,481 | 17,566,464 |
| Lemons | 956,920 | 2,770,313 | 2,993,738 |
| Pomeloes (grape fruit) | 710,040 | 1,189,250 | 2,060,610 |
| Limes | 45,387 | 11,318 | 12,478 |
| Tangerines | 27,271 | 38,752 | 68,770 |
| Mandarins | 7,227 | 3,896 | 6,553 |
| Kumquats | 1,988 | 1,112 | 2,826 |
| Citrons | 8 | 6 | 9 |
| Total citrus | 11,486,768 | 23,502,128 | 22,711,448 |
| Noncitrus fruits— | | *Pounds.* | |
| Figs | 821,640 | 35,060,395 | 808,810 |
| Pineapples | [1] 36,191,389 | [2] 778,651 | 734,090 |
| Olives | 846,175 | 16,405,493 | 404,574 |
| Bananas | 23,114 | [3] 10,060 | 5,661 |
| Guavas | 15,347 | 354,062 | 11,628 |
| Avocados (aguacates) | 12,054 | [2] 4,920 | 10,100 |
| Mangoes | 4,904 | [4] 5,278 | 5,739 |
| Persimmons (Japanese) | 16,491 | [5] 6,723 | 9,087 |
| Loquats | 3,791 | [4] 4,541 | 5,880 |
| Pomegranates | 8,933 | 152,825 | 4,203 |
| Dates | 4,551 | 9,947 | 533 |
| Total noncitrus | ........ | ........ | 1,995,305 |
| Grapes | [6] 223,701,522 | [7] 2,571,065,205 | 22,027,961 |

[1] Number of plants. [2] Crates. [3] Bunches. [4] Boxes.
[5] Bushels. [6] Vines of bearing age. [7] Pounds.

TABLE 1.—*Fruit crops of the United States, 1909*—Continued.

| Crop. | Trees of bearing age, 1910. | Production, 1909. | Value, 1909. |
|---|---|---|---|
| Small fruits: | *Acreage.* | *Quarts.* | |
| Strawberries | 143,045 | 255,702,035 | $17,913,926 |
| Blackberries and dewberries | 49,004 | 55,343,570 | 3,909,831 |
| Raspberries and loganberries | 48,668 | 60,918,196 | 5,132,277 |
| Cranberries | 18,431 | 38,243,060 | 1,755,613 |
| Currants | 7,862 | 10,448,532 | 790,431 |
| Gooseberries | 4,765 | 5,282,843 | 417,034 |
| Other berries | 685 | 627,627 | 55,369 |
| Total small fruits | 272,460 | 426,565,863 | 29,974,481 |
| Total all fruits | | | 217,576,542 |

The principal fruits of the various classes were the following, the figures for 1909 being taken from the Thirteenth Census of the United States:

### DECIDUOUS TREE FRUITS.

*Apples.*—From the viewpoint of quantity produced, value of product, and wide distribution of cultivation, the apple is the most important fruit grown in the United States. The number of farms reporting apple trees of bearing age in 1910 was 2,980,000, practically one-half of all the farms in the United States at that time. The total production of apples in 1909 was 146,000,000 bushels, equivalent in round numbers to 49,000,000 barrels of 3 bushels each. The leading States were New York with 8,470,000 barrels, Michigan 4,111,000 barrels, Pennsylvania 3,349,000 barrels, and Missouri 3,323,000 barrels. In 1915 and 1916 the apple crop of the United States, according to reports of the Bureau of Crop Estimates, amounted to 77,000,000 and 68,000,000 barrels, respectively. It should be borne in mind that the foregoing figures refer to agricultural production and not to a so-called commercial crop.

From recent investigations made by the Bureau of Crop Estimates it is estimated that about 18 per cent of the 1915 apple crop consisted of "summer" apples, 25 per cent "fall," and 57 per cent "winter" apples. The three leading varieties were the Ben Davis, which comprised 14.5 per cent of the total crop; the Baldwin, 10.9 per cent; and the Winesap, 7.3 per cent. It is estimated that in the disposal of the crop nearly 56 per cent was sold from farm or orchard (excluding that used for cider), 10 per cent was used to make cider, 19 per cent was consumed on farms for human purposes other than as cider, and the remaining 15 per cent was wasted or eaten by live stock.

*Peaches and nectarines.*—The production in 1909 was 35,500,000 bushels. California ranked first in the production of these fruits with 9,250,000 bushels and Georgia second with 2,500,000 bushels.

No other State had a production so large as 2,000,000 bushels. For the years 1915 and 1916 the Bureau of Crop Estimates reports the total production of peaches as 63,000,000 bushels and 37,000,000 bushels, respectively.

*Plums and prunes.*—The production of plums and prunes in 1909 was 15,500,000 bushels. California was the leading State with 9,318,000 bushels, Oregon second with 1,748,000 bushels, and Washington third with 1,032,000 bushels.

*Pears.*—The production of pears in 1909 amounted to 8,841,000 bushels. The chief producing States were California with 1,928,000 bushels and New York with 1,343,000 bushels. In 1915 the pear crop of the United States, according to reports of the Bureau of Crop Estimates, was 11,216,000 bushels, and in 1916, 10,377,000 bushels.

*Cherries.*—The production of cherries in 1909 was 4,126,000 bushels. California ranked first with 501,000 bushels and Pennsylvania second with 475,000 bushels.

### TROPICAL AND SUBTROPICAL FRUITS.

*Citrus.*—The principal citrus fruits grown in the United States are oranges, lemons, and grapefruit. The cultivation of these fruits is virtually confined to California and Florida. In 1909 there were produced in the United States 19,487,000 boxes of oranges, 2,770,000 boxes of lemons, and 1,189,000 boxes of grapefruit. Practically all of the lemons and 74 per cent of the oranges were grown in California, while virtually all of the grapefruit and 25 per cent of the oranges were grown in Florida.

During the season 1913-14 there were shipped out of California, according to figures of the California State Board of Agriculture 45,306 carloads of oranges and 3,032 carloads of lemons, as against 39,744 carloads of oranges and 7,068 carloads of lemons in 1914–15. A California carload is estimated to average about 396 boxes of oranges or 336 boxes of lemons.

The production of oranges and grapefruit in Florida during the season 1913–14, as reported by the Commissioner of Agriculture of that State, amounted to 6,666,000 boxes and 2,211,000 boxes, respectively.

*Noncitrus.*—The principal noncitrus fruits grown were figs, pineapples, and olives. In 1909 there were produced in the United States 35,060,000 pounds of figs, 779,000 crates of pineapples, and 16,405,000 pounds of olives. Two-thirds of the figs and practically all of the olives were grown in California, while Florida reported virtually all of the pineapples.

With regard to the disposal of the olive crop of 1915, the California Olive Association estimates the production of olive oil in California at 1,000,000 gallons and of packed olives at 300,000 cases of 6 gallons to the case.

*Grapes.*—The production of grapes in 1909 was 2,571,000,000 pounds, valued at $22,628,000. While California produced 77 per cent of the total crop, the value of the grapes of that State amounted to only 49.2 per cent of the total value. New York was second in production with 253,000,000 pounds and Michigan third with 121,000,000 pounds.

According to a report of the California State Board of Viticultural Commissioners, dated March 15, 1914, the area planted to grapes in California amounts to 330,000 acres. Of this area, it is estimated that about 170,000 acres are planted to wine grapes, 110,000 acres to raisin grapes, and 50,000 acres to table grapes. The total production of fresh grapes in 1914 from the 330,000 acres is reported as 1,848,380,000 pounds, or 924,190 tons.[1] In the disposal of the California vintage of 1914 it is estimated that about 475,190 tons of fresh grapes, valued at $5,250,000, were delivered to wineries, 324,000 tons were dried into raisins, and 125,000 tons were sold as table grapes.

### SMALL FRUITS.

*Strawberries.*—The total production of strawberries in the United States in 1909 was 256,000,000 quarts. Maryland ranked first with 24,000,000 quarts and New Jersey second with 19,000,000 quarts. With regard to acreage, the leading States were Maryland, Tennessee, Missouri, New Jersey, and Michigan. In value of strawberries produced, New York was the leading State, followed by California, Missouri, Maryland, and Michigan.

*Raspberries and loganberries.*—The total production of these fruits in the United States in 1909 amounted to 60,918,000 quarts. New York ranked first with 14,752,000 quarts and Michigan second with 8,382,000 quarts.

Nearly four-fifths of the total value of all fruit grown in the United States in 1909 was contributed by five items, namely, apples 38.3 per cent, peaches and nectarines 13.2 per cent, grapes 10.1 per cent, strawberries 8.2 per cent, and oranges 8.1 per cent.

### FRUIT PRODUCTS.

#### FARM OUTPUT.

In 1909 there were produced on farms in the United States 358,040,000 pounds of dried fruits (including raisins and dried grapes), 32,584,000 gallons of cider, 7,247,000 gallons of vinegar, and 18,636,000 gallons of wine and grape juice.

California produced 93.2 per cent of the dried fruits and 86 per cent of the wine and grape juice.

Pennsylvania ranked first in the production of cider and vinegar, New York second, and Michigan third.

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[1] Throughout this bulletin, 1 ton equals 2,000 pounds.

### FACTORY OUTPUT.

The factory output of fruit products in the United States in 1909 amounted to 5,529,000 cases of canned fruits, valued at $13,015,000; 401,336,000 pounds of dried fruits, valued at $19,894,000; vinegar and cider to the value of $8,448,000; and vinous liquors to the value of $13,121,000.

*Canned fruits.*—The principal fruits canned in 1909 in establishments engaged primarily in the canning industry were peaches, 1,467,000 cases, valued at $3,754,000; apples, 1,206,000 cases, valued at $1,899,000; pears, 638,000 cases, valued at $1,833,000; apricots, 630,000 cases, valued at $1,825,000; berries, 816,000 cases, valued at $1,755,000; and cherries, 390,000 cases, valued at $1,019,000.

California furnished 80 per cent of the total value of canned peaches, 72 per cent of the canned pears, practically all of the canned apricots, and 48 per cent of the canned cherries. New York led in the production of canned apples and berries and was second in the production of canned cherries.

*Dried fruits.*—The principal dried fruits packed in 1909 in establishments engaged primarily in the packing industry were prunes, 138,498,000 pounds, valued at $5,130,000; raisins, 111,775,000 pounds, valued at $4,838,000; apples, 44,568,000 pounds, valued at $3,098,000; peaches, 46,843,000 pounds, valued at $2,423,000; and apricots, 29,206,000 pounds, valued at $2,277,000.

California reported all of the raisins and dried apricots, practically all of the dried peaches, and 86 per cent of the prunes. New York was the leading State in the production of dried apples, reporting 75 per cent of the value of this product, and California ranked second with 15.5 per cent.

*Vinegar and cider.*—Of the total value of vinegar and cider manufactured in cider-making establishments, New York contributed 26.6 per cent. Michigan ranked second in importance.

*Vinous liquors.*—This industry includes the manufacture of various kinds of wine and champagne. It is confined to a few States. California furnished 68.1 per cent of the total value of these products manufactured in wineries in 1909, New York 13.8 per cent, Ohio 9.9 per cent, Missouri 2.6 per cent, and New Jersey 1.3 per cent.

### FRUIT TRADE OF THE UNITED STATES.

Statistics of the fruit trade of the United States for the fiscal years ending June 30, 1910 and 1915, are given in the following table. The fiscal year 1910 corresponds with the census production year 1909:

**TABLE 2.**—*Fruit trade of the United States, with foreign countries and insular possessions, 1910 and 1915.*

(United States Department of Commerce.)

| Item. | Year ending June 30— | | | |
|---|---|---|---|---|
| | 1910 | | 1915 | |
| | Quantity. | Value. | Quantity. | Value. |
| **Exports (of domestic fruits) to foreign countries:** | | *Dollars.* | | *Dollars.* |
| Apples, dried ... pounds | 25,076,618 | 2,056,692 | 42,589,169 | 3,270,658 |
| Apples, green or ripe ... barrels | 922,078 | 3,175,433 | 2,351,501 | 8,087,466 |
| Apricots, dried ... pounds | 12,028,834 | 1,218,423 | 23,764,342 | 2,241,061 |
| Berries | | (1) | | 535,479 |
| Lemons | | (1) | | 372,781 |
| Oranges ... boxes | 932,118 | 2,213,905 | 1,759,405 | 3,851,013 |
| Peaches, dried ... pounds | 2,617,069 | 151,520 | 14,464,655 | 834,813 |
| Pears, green or ripe | | 302,958 | | 992,497 |
| Prunes ... pounds | 89,014,880 | 4,016,554 | 43,478,892 | 3,274,197 |
| Raisins and other dried grapes ... do | 8,526,114 | 417,403 | 24,845,414 | 1,718,547 |
| All other, green, ripe, or dried | | 2,119,210 | | 2,717,449 |
| Fruits, prepared or preserved: | | | | |
| Canned | | 2,656,019 | | 6,064,765 |
| All other | | 176,474 | | 269,180 |
| Total | | 18,504,591 | | 34,229,906 |
| **Imports from foreign countries:** | | | | |
| Bananas ... bunches | 38,156,659 | 11,642,693 | 41,091,585 | 13,512,960 |
| Currants, dried ... pounds | 33,326,030 | 1,190,020 | 30,350,527 | 1,209,273 |
| Dates ... do | 22,693,713 | 516,704 | 24,949,374 | 420,208 |
| Figs ... do | 17,362,197 | 775,319 | 20,779,730 | 1,024,495 |
| Grapes ... cubic feet | 1,365,310 | 1,682,994 | 1,323,928 | 1,523,547 |
| Lemons ... pounds | 160,214,785 | 3,136,933 | | 3,730,075 |
| Olives ... gallons | 4,555,075 | 1,659,801 | 3,622,275 | 1,607,903 |
| Oranges ... pounds | 4,676,118 | 82,457 | | 50,022 |
| Pineapples | | 1,317,462 | | 1,309,750 |
| Raisins and other dried grapes ... pounds | 5,042,683 | 296,047 | 2,808,806 | 238,958 |
| Preserved fruits | | 956,368 | | 1,022,968 |
| All other | | 920,362 | | 1,431,242 |
| Total | | 24,177,160 | | 27,081,396 |
| **Shipments from the United States to Hawaii:** | | | | |
| Apples, green or ripe ... barrels | 23,487 | 50,459 | 19,688 | 64,865 |
| Oranges ... boxes | 32,363 | 70,286 | 52,428 | 104,957 |
| All other, green, ripe, or dried | | 57,560 | | 105,953 |
| Prepared or preserved— | | | | |
| Canned | | 42,013 | | 88,133 |
| All other | | 8,484 | | |
| Total | | 228,802 | | 363,908 |
| **Shipments from the United States to Porto Rico:** | | | | |
| Raisins and other dried grapes ... pounds | 348,268 | 22,441 | 223,103 | 15,703 |
| All other, green, ripe, or dried | | 30,891 | | 47,819 |
| Prepared or preserved | | 70,966 | | 46,137 |
| Total | | 124,298 | | 109,659 |
| **Shipments to the United States from Hawaii:** | | | | |
| Bananas ... bunches | | (2) | 230,144 | 147,021 |
| Pineapples, fresh | | (2) | | 52,928 |
| Pineapples, canned | | 1,548,950 | | 5,986,190 |
| All other | | 224,375 | | 2,637 |
| Total | | 1,773,325 | | 6,188,776 |
| **Shipments to the United States from Porto Rico:** | | | | |
| Fruits, green, ripe, or dried— | | | | |
| Grapefruit ... boxes | | (2) | 276,550 | 834,356 |
| Oranges ... do | 296,018 | 582,616 | 200,268 | 378,092 |
| Pineapples, fresh | | (2) | | 1,723,694 |
| Pineapples, canned | | 106,617 | | 84,733 |
| All other | | 727,163 | | 9,621 |
| Total | | 1,416,396 | | 3,030,496 |

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[1] Included in "all other green, ripe, or dried" in 1910.

[2] Included in "all other" in 1910.

## CANADA.

### AREA AND PRODUCTION OF FRUITS.

Orchards in Canada had an area in 1911 of 403,596 acres as compared with 356,106 acres in 1901, vineyards 9,836 acres in 1911 as against 5,600 acres in 1901, and small fruits 17,495 acres in 1911 as compared with 13,411 acres in 1891. Acreage of small fruits in 1901 was included with vegetables.

The principal orchard fruits grown in Canada are apples, peaches, plums, pears, and cherries, while grapes, strawberries, currants, and gooseberries are the leading small fruits.

TABLE 3.—*Fruit crops of Canada, 1900 and 1910.*

[Census of the Dominion of Canada.]

| Kind. | Bearing trees. | | Production. | |
|---|---|---|---|---|
| | 1911 | 1901 | 1910 | 1900 |
| Orchard fruits: | *Number.* | *Number.* | *Bushels.* | *Bushels.* |
| Apple | 10,617,372 | 11,025,789 | 10,618,666 | 18,626,186 |
| Peach | 839,288 | 819,985 | 646,826 | 545,415 |
| Pear | 581,704 | 617,293 | 504,171 | 531,837 |
| Plum | 1,075,130 | 1,452,269 | 508,994 | 557,875 |
| Cherry | 741,992 | 903,140 | 238,974 | 336,751 |
| Other | 146,659 | 141,870 | 47,789 | 70,396 |
| Total | 14,002,145 | 14,960,346 | 12,565,420 | 20,668,460 |
| Small fruits: | | | | |
| Grapes......pounds | ........ | ........ | 32,898,438 | 24,302,634 |
| Strawberries......boxes | ........ | ........ | 18,686,662 | ........ |
| Currants and gooseberries......quarts | ........ | ........ | 3,830,609 | 21,707,791 |
| All other......boxes | ........ | ........ | 9,000,208 | ........ |

Ontario was the leading Province in the production of fruits, reporting in 1910, 6,459,000 bushels of apples, 600,000 bushels of peaches, 424,000 bushels of pears, 347,000 bushels of plums, and 146,000 bushels of cherries.

### IMPORTS.

Bananas, oranges, grapefruit, raisins, and wine are the chief items imported. During the five fiscal years ended March 31, 1909–1913, there was imported for consumption an annual average of 1,850,000 bunches of bananas, valued at $1,826,000; 21,363,000 pounds of raisins, valued at $1,133,000; oranges and grapefruit to the value of $2,656,000; and wine to the value of $1,229,000. Nearly all of the bananas, over one-half of the raisins, and nine-tenths of the oranges and grapefruit were obtained from the United States, while France, Spain, Portugal, and Japan supplied most of the wines.

Other fruits and fruit products of importance imported during the five years named, together with their average annual value, were dried apples, $14,000; green apples, $499,000; apricots, nectarines, pears, and quinces, $245,000; berries, $328,000; canned fruits, $372,-

000; cherries, $58,000; cranberries, $93,000; dried currants, $551,000; dates, $154,000; figs, $192,000; grapes, $277,000; lemons and limes, $650,000; peaches, $234,000; pineapples, $265,000; plums, $194,000; prunes, $495,000; and olive oil, $190,000.

### EXPORTS.

The principal fruit exported from Canada is apples. During the five years 1909–1913 there were exported from Canada on an average 1,242,000 barrels of apples annually, valued at $3,626,000. Great Britain took 93 per cent of these apples, Germany 2.5 per cent, and the United States 1.7 per cent. Of the total value of fruit exported from Canada during the five years named 82.3 per cent was contributed by apples.

In addition to fresh apples there were exported from Canada during the five years 1909–1913 dried apples to the value of $299,000 annually, berries $123,000, canned or preserved fruits $226,000, cider $28,000, and wine $7,000.

## CENTRAL AMERICA.

*Costa Rica.*—The growing of bananas for export is the principal fruit industry of Costa Rica. Nearly one-half of the total value of all exports from that country is derived from this one item. During the five years 1909–1913 exports of bananas averaged 9,918,000 bunches annually, valued at $4,615,000. Four-fifths of these bananas went to the United States and practically all of the rest to the United Kingdom.

Small quantities of oranges were also exported, principally to the United States.

The principal fruits and fruit products imported into Costa Rica during the five years 1909–1913 and their average annual value were fresh fruits $6,758, dried fruits $10,027, preserved fruits $11,577, olive oil $12,580, and wines $114,000.

*Guatemala.*—Bananas constitute one of the principal sources of wealth in Guatemala. In 1913 the value of bananas exported amounted to $826,000, as compared with $667,000 in the year preceding.

*Honduras.*—During the fiscal year ended July 31, 1913, the value of bananas exported from Honduras amounted to $1,654,000, or one-half of the total value of all exports. These bananas are shipped principally from Puerto Cortez, Ceiba, and Trujillo. Those from Puerto Cortez average about $1,000,000 a year.

*Nicaragua.*—Bananas are grown in large quantities in the Bluefields section and shipped to New Orleans. Exports for the four years 1911–1914 averaged 1,458,000 bunches annually, valued at $424,000.

## MEXICO.

### PRODUCTION.

A wide variety of fruits is grown in Mexico, ranging from the apple, peach, cherry, plum, quince, and grape of the Temperate Zone to the orange, lime, lemon, banana, pineapple, fig, zapote, mango, mamey, avocado (aguacate), and guava of the Semitropical and Tropical Zones. Oranges and bananas are the most important fruits grown in Mexico. In 1907 the production of these fruits amounted to 83,814,000 pounds and 80,492,000 pounds, respectively.

### IMPORTS OF FRUITS AND FRUIT PRODUCTS.

During the four fiscal years ending June 30, 1909–1912, there were imported annually into Mexico on an average 4,021,000 pounds of dried fruits, valued at $227,000; 156,000 pounds of preserved fruits, valued at $17,000; 1,494,000 pounds of pickled fruits, valued at $66,000; 1,230,000 pounds of olive oil, valued at $195,000; and 22,297,000 pounds of wines, valued at $1,655,000. The United States and Spain supplied most of the dried and preserved fruits and Spain the larger part of the pickled fruits and olive oil. The wines were obtained chiefly from Spain and France.

### EXPORTS OF DOMESTIC FRUITS.

Exports of domestic fruits from Mexico, comprising strawberries, avocados, bananas, lemons, oranges, etc., averaged 24,196,000 pounds annually, valued at $247,000, during the five-year period 1908–1912. Ninety-three per cent of these fruit exports was shipped to the United States and nearly all of the remainder to Canada.

## WEST INDIES.

### BRITISH WEST INDIES.

*Bahamas.*—The principal fruit exported from the Bahama Islands is canned pineapples. During the four years 1909–1912 there were exported 36,737 cases, valued at $35,724, as compared with 31,000 and 33,000 cases in 1913 and 1914, respectively. Small quantities of grapefruit and oranges are also exported. The United States is the chief customer for these fruits.

*Barbados.*—During the four years 1909–1912 the average annual value of bananas exported was $8,777. Nearly all of the bananas were shipped to the United Kingdom.

*Jamaica.*—The growing of bananas for export is the principal industry of Jamaica. In the season 1914–15 the area under bananas amounted to 85,854 acres, as compared with an average of 82,064 acres for the four preceding years. Exports during the four years 1909–1912 averaged 15,117,000 bunches annually, valued at $6,379,000, as compared with 11,598,000 bunches, valued at

$4,809,000, in 1913. Nearly all of the bananas are shipped to the United States. There were also exported grapefruit to the value of $92,170 annually, oranges $207,000, and lime juice $19,258.

*Leeward Islands.*—The growing of limes is the principal fruit industry of the islands of this group, especially in Dominica, where the industry has attained its highest development. During the five years 1909–1913 the lime crop of Dominica averaged 354,000 barrels yearly. The flour barrel used for measuring limes will average about 160 pounds of fruit. Calculated on this basis the average annual production was 56,640,000 pounds. The average annual value of exports of limes and lime products during the three years 1911–1913 was $508,090. There were also exported from Dominica small quantities of oranges and orange oil.

*St. Lucia.*—The cultivation of limes is making rapid strides and seems likely to assume an important place in the economics of the island. Exports of limes and lime products increased from $1,411 in 1911 to $5,280 in 1912 and $15,220 in 1913.

*Trinidad and Tobago.*—The area devoted to the cultivation of limes and oranges in the season 1913–14 was 1,123 acres. The value of fruit exported has increased from $3,908 in 1905 to $57,396 in 1914.

### CUBA.

Among the fruits grown in Cuba are the banana, pineapple, orange, lime, avocado (aguacate), anon (custard apple), fig, guava, mamey, and sapote.

*Exports.*—During the five years 1909–1913 there was exported from Cuba an annual average of 69,063,000 pounds of pineapples, valued at $1,189,000; 82,223,000 pounds of bananas, valued at $771,000; 6,195,000 pounds of oranges, valued at $116,000; and 84,233 pounds of limes, valued at $1,521. Practically all of these fruits were shipped to the United States.

*Imports.*—The principal fruits and fruit products imported into Cuba during the five years 1909–1913 and their average annual value were dried apples, $5,740; fresh apples, $59,000; canned fruit, $73,000; grapes, $39,000; prunes, $15,300; raisins, $27,300; olive oil, $928,000; and wines, $1,574,000.

### DOMINICAN REPUBLIC.

The principal fruit exported from the Dominican Republic is the banana. Shipments of bananas from Puerto Plata during the three years 1912–1914 ranged between 592,000 bunches in 1913, valued at $296,000, and 130,000 bunches in 1914, valued at $65,000. Practically all of this fruit was shipped to the United States.

### FRENCH WEST INDIES.

Small quantities of pineapples are exported from Guadeloupe, and of bananas, pineapples, and citrate of lime from Martinique.

### HAITI.

Statistics of the commerce of Haiti are meager and fragmentary. In 1913 there were exported 601,000 pounds of orange peel, as compared with 622,000 pounds in 1912.

### PORTO RICO.

The principal fruits cultivated in Porto Rico are pineapples, oranges, and grapefruit. The value of fruit exported during the fiscal year ended June 30, 1915, was the largest in the history of the island, amounting to $3,031,000.[1] Of this value, pineapples contributed $1,724,000, grapefruit $834,000, and oranges $378,000.

## SOUTH AMERICA.

### ARGENTINA.

#### PRODUCTION.

Grape growing is the most important fruit industry in Argentina. During the five years 1909–1913 the area devoted to the cultivation of grapes averaged 265,000 acres yearly, the quantity of grapes sent to wineries 1,324,000,000 pounds, and the production of wine 107,405,000 gallons. Mendoza is the leading Province in the production of grapes. Considerable quantities are also grown in the Provinces of San Juan and Entre Rios.

Statistics of production of other fruits are lacking. However, the Argentine census of 1908 reports the number of fruit trees in Argentina as 14,343,000. Slightly more than one-half of these is credited to the Province of Buenos Aires. The total number of peach trees in Argentina numbered 7,908,000, orange trees 2,117,000, apple trees 1,185,000, pear trees 459,000, apricot trees 312,000, olive trees 98,000, and lemon trees 64,000, the remainder being made up of fruit trees not specified. Buenos Aires was the leading Province in the growing of peaches and apples, reporting an area of 32,017 acres carrying 4,839,000 peach trees, and an area of 5,283 acres carrying 1,035,000 apple trees. With reference to orange culture, Corrientes is the leading Province, reporting an area of 15,987 acres carrying 1,514,000 trees.

#### IMPORTS.

The value of fresh, dried, and prepared or preserved fruits imported into Argentina during the five years 1909–1913 averaged $1,779,000. Fresh fruits contributed 49 per cent of this value, prepared or preserved fruits 31.6 per cent, and dried fruits 19.4 per cent. In addition, imports of olive oil averaged $3,780,000 annually during the five years 1909–1913, and wines $9,738,000 annually.

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[1] Nearly all of this fruit was shipped to the United States.

The value of imports is the official valuation fixed by the valuation schedule of the tariff.

The principal fruits imported into Argentina during the five years 1909–1913 and their average annual value were olives $387,000, apples $201,000 (year 1913), oranges $201,000, figs $138,000, bananas $117,000, raisins $106,000, plums $82,000, lemons $55,000, dates $29,000, grapes $12,000, and preserved fruits $112,000.

### EXPORTS.

The value of exports of fruit from Argentina during the five years 1909–1913 averaged $51,000 annually. These exports went chiefly to Brazil and Uruguay. The value is based on the current market price.

## BRAZIL.

### IMPORTS.

Imports of fruit for the three years 1910–1912 averaged 24,685,000 pounds, valued at $2,432,000. Fresh fruits contributed 56.3 per cent of this value, dried fruits 25 per cent, and prepared or preserved fruits 18.7 per cent. In 1913 and 1914 the value of these imports was $2,804,000 and $1,721,000, respectively. The principal items imported and their average annual value were dried fruits $607,000, olives $398,000, grapes $393,000, and apples $206,000.

Imports of olive oil during the four years 1909–1912 averaged 8,340,000 pounds annually, valued at $1,679,000, and of wines 148,380,000 pounds annually, valued at $10,988,000. Portugal, Italy, Spain, and France supplied most of the olive oil and wines.

### EXPORTS.

Exports of fruits from Brazil for the three years 1910–1912 averaged $747,000 annually. Fresh fruits contributed 92.6 per cent of this value and prepared or preserved fruits 7.1 per cent. In 1913 and 1914 the value of fruit exported was $824,000 and $875,000, respectively. The principal fruits exported during the three years 1910–1912 and their average annual value, were bananas $641, 000, pineapples $37,000, oranges $11,788, and tangerines $3,805.

## CHILE.

### AREA AND PRODUCTION.

The varieties of fruits cultivated in Chile are very numerous, including peaches, apples, plums, prunes, quinces, pears, grapes, oranges, lemons, figs, etc.

Of these fruits, the most important is the grape. During the three years 1911–1913 the area devoted to the cultivation of the vine averaged 140,578 acres annually, as compared with 162,895 acres in 1914. French vines occupied 21.1 per cent of the area during the five-year period mentioned and native vines the remainder. In 1914 French vines numbered 75,453,000, as against 192,111,000 native vines. The vintage yield during the five years 1909–1913 averaged 36,217,000 gallons of wine annually, 7,022,000 gallons of chichas (a drink made from must), 5,709,000 gallons of chacolies (a sour wine made from green grapes), 485,279 gallons of brandy, and 1,600,000 pounds of raisins. The 1914 vintage produced 55,213,000 gallons of wine, 12,066,000 gallons of chichas, 10,474,000 gallons of chacolies, 665,180 gallons of brandy, and 1,536,000 pounds of raisins.

The area devoted to the cultivation of orchard fruits during the four years 1910–1913 averaged 29,283 acres, as compared with 42,926 acres in 1914; and the average annual production of the principal fruits was as follows: Apples 21,484,000 pounds (year 1914), cider 737,000 gallons, figs 2,737,000 pounds, dried peaches 2,365,000 pounds, olives 1,006,000 pounds, prunes 423,000 pounds, and cherries 197,000 pounds.

#### EXPORTS.

The value of exports of fruits from Chile during the five years 1909–1913 averaged $184,000 yearly. Dried fruit, principally peaches and raisins, contributed 77.6 per cent of this value, prepared or preserved fruits 17.4 per cent, and fresh fruits 5 per cent. Wine exports averaged $39,000 annually.

#### IMPORTS.

Imports of fruits into Chile for the five years 1909–1913 averaged 1,222,000 pounds annually, valued at $99,000. Nearly all of these imports consisted of fresh fruits shipped in from Peru. Imports of olive oil and other oils for table use during this period averaged 17,255,000 pounds annually, valued at $1,201,000. The United States and Italy supplied most of these oils.

### PARAGUAY.

The growing of oranges is the principal fruit industry of Paraguay. It is estimated that the number of orange trees of producing age in 1913 was 1,500,000. In that year there were exported from Paraguay 164,271,000 oranges, 3,768,000 mandarins, 5,265 pineapples, and 38,142 bunches of bananas.

### URUGUAY.

#### AREA AND PRODUCTION.

Of the total area under fruit trees in 1908, approximately one-half was devoted to the cultivation of peaches and one-fourth to oranges.

TABLE 4.—*Orchard fruit crops of Uruguay, 1908.*

| Kind of tree. | Area cultivated. | Number of trees. | Production. |
|---|---|---|---|
| | *Acres.* | | *Pounds.* |
| Orange | 16,884 | 501,119 | 6,292,759 |
| Lemon | 1,403 | 40,332 | 815,901 |
| Peach | 33,418 | 2,095,597 | 14,229,895 |
| Pear | 6,716 | 229,198 | 1,791,650 |
| Apple | 4,935 | 118,391 | 850,889 |
| Plum | 1,436 | 68,278 | 219,777 |
| Cherry, sweet | 761 | 50,519 | 23,847 |
| Cherry, sour | 1,114 | 55,301 | 273,242 |
| Olive | 1,458 | 125,828 | 104,463 |
| Total | 68,125 | 3,284,563 | 23,602,423 |

## VINEYARDS.

During the five years 1909–1913 the average area under vines was 14,386 acres, number of producing vines 21,528,000, production of grapes 29,255 tons, and production of wine 4,111,000 gallons.

TABLE 5.—*Vineyards of Uruguay, 1908–9 to 1912–13.*

| Season. | Area. cultivated. | Number of producing vines. | Production. | |
|---|---|---|---|---|
| | | | Grapes. | Wine. |
| | *Acres.* | | *Tons of 2,000 lbs.* | *Gallons.* |
| 1908–9 | 13,574 | 19,636,543 | 30,240 | 4,270,304 |
| 1909–10 | 14,080 | 20,689,479 | 31,285 | 4,490,295 |
| 1910–11 | 14,006 | 20,410,430 | 27,089 | 3,884,250 |
| 1911–12 | 15,188 | 22,772,976 | 20,806 | 2,788,803 |
| 1912–13 | 15,082 | 24,132,869 | 36,854 | 5,132,962 |

## IMPORTS.

The value of imports of fruit into Uruguay during the three years 1909–1911 averaged $282,000 annually. Dried fruits contributed 50.3 per cent of this value, fresh fruits 39.3 per cent, and preserved or pickled fruits 10.4 per cent. The principal fruits imported during the three years 1909–1911 and their average annual value were raisins $60,212, figs $41,087, oranges $38,574, olives $25,754, plums $25,242, dried peaches $22,269, bananas $21,549, dates $17,330, and apples $4,622.

Imports of olive oil averaged $526,500 annually and of wine $1,714,000. Spain and Italy supplied the bulk of the olive oil and wine.

## EXPORTS.

The value of fruit exported from Uruguay during the three-year period 1909–1911 averaged $44,952 annually, as compared with $47,831 in 1912. The principal fruits specified among these exports were peaches, oranges, pears, olives, and cherries.

# EUROPE.

## AUSTRIA-HUNGARY.

### AREA AND PRODUCTION.

*Austria.*—During the five years 1909–1913 the average annual production of fruit in Austria was as follows:

Apples, pears, etc., 1,315,000,000 pounds; cherries, plums, etc., 1,075,000,000 pounds; citrus fruits (reported only in 1913), 75,000 pounds; figs, 15,306,000 pounds; and grapes for table use, 10,210,000 pounds.

There was also produced during this period an annual average of 10,083,000 pounds of olive oil and 110,734,000 gallons of wine. Statistics of the production of the various fruits of Austria and of wine for each of the five years 1909–1913 are given in the following table:

TABLE 6.—*Production of fruit and wine in Austria.*

| Kind. | 1909 | 1910 | 1911 | 1912 | 1913 |
|---|---|---|---|---|---|
| Grapes for table use...pounds.. | 10,696,499 | 8,929,512 | 10,482,212 | 12,027,416 | 8,914,741 |
| Apples, pears, etc.......do.... | 1,043.832,906 | 1,415,680,363 | 951,926,659 | 2,065,581,231 | 1,099,817,841 |
| Cherries, plums, etc.....do.... | 1,735,670,337 | 911,423,968 | 570,496,026 | 1,586,722,049 | 569,140,418 |
| Figs.....................do.... | 16,172,284 | 18,734,250 | 15,392,517 | 14,612,530 | 11,619,565 |
| Citrus fruit..............do.... | .............. | .............. | .............. | .............. | 75,177 |
| Wine.................gallons.. | 165,174,168 | 67,281,378 | 101,352,889 | 104,872,135 | 114,989,186 |

*Hungary.*—Statistics of fruit in Hungary for recent years are confined to the area under vines, production of wine, and grapes sold. During the three years 1909–1911 the average area of the vineyards of Hungary was 864,000 acres; quantity of wine produced, 106 million gallons; grapes sold, 24 million pounds; and the average annual value of all products of the vine $30,993,000.

### IMPORTS.

Imports of fruits into Austria-Hungary during the five years 1909–1913 averaged 399,806,000 pounds annually, valued at $9,496,000. Fresh fruits contributed 60.9 per cent of this value, dried fruits 34.6 per cent, and prepared or preserved fruits 4.5 per cent. In addition, imports of wines averaged 8,841,000 pounds annually, valued at $1,682,000, and of edible olive oil 7,211,000 pounds, valued at $708,000.

The principal fruits imported into Austria-Hungary are oranges, figs, lemons and cedrates, and raisins. During the five years 1909–1913 the average annual imports of these fruits were as follows: Oranges 156,719,000 pounds, valued at $2,598,000; figs 67,331,000 pounds, valued at $1,813,000; lemons and cedrates 73,686,000 pounds, valued at $1,393,000; and raisins 20,416,000 pounds, valued at $1,159,000.

Oranges and lemons were obtained chiefly from Italy, figs from Greece, Italy, and Turkey, raisins from Greece and Spain, wines from France, and olive oil from Greece, Italy, and France.

Other fruits and fruit products imported during the period named and their average annual value were apples, pears, and quinces $988,000, dates $169,000, cherries and pickled fruits $137,000 each, prunes $126,000, plum marmalade $123,000, grapes $93,000, plums $90,000, apricots and pineapples $78,000 each, preserved citrus fruits and peel $67,000, olives $66,000, dried currants $17,000, and olive oil for industrial uses $178,000.

### EXPORTS.

Exports of fruits from Austria-Hungary during the five years 1909–1913 averaged 273,879,000 pounds annually, valued at $5,755,000. Fresh fruits contributed 83.7 per cent of this value, dried fruits 12.7 per cent, and prepared or preserved fruits 3.6 per cent. In addition, exports of wines other than sparkling averaged $1,271,000 annually, and of edible olive oil $32,000.

The principal fruits exported from Austria-Hungary were apples, pears, and quinces. During the five years 1909–1913 exports of these fruits averaged 165,898,000 pounds annually, valued at $3,076,000. Of the other fruits exported the more important and their average annual value were prunes $727,000, lemons and cedrates $435,000, plums $332,000, grapes $268,000, oranges $209,000, pickled fruits $151,000, apricots $107,000, cherries $88,000, and peaches $13,000.

The bulk of the fruits exported went to Germany and the larger part of the olive oil to Italy. Fifty-two per cent of the wines was shipped to Switzerland and 41 per cent to Germany.

## BELGIUM AND NETHERLANDS.

### BELGIUM.

*Area.*—The area under orchard fruits in Belgium in 1910 amounted to 157,000 acres. On 10,546 acres of this area other crops were planted between the trees. Official statistics of the production of the various kinds of fruits are not available.

*Imports.*—The total value of imports of fruits, exclusive of preserved fruits, into Belgium during the five years 1909–1913 averaged $3,838,000 annually. Fresh fruits contributed 55.2 per cent of this value and dried fruits 44.8 per cent. In addition, imports of wine averaged $7,057,000 annually and of olive oil $603,000 annually.

Citrus fruits and apples are the chief fruits imported. During tho five years 1909–1913 there was imported annually an average of 53,325,000 pounds of citrus fruits, valued at $1,240,000, and 30,447,000 pounds of fresh apples, valued at $568,000. Of the other fruits imported during the period named, the principal ones and their average annual value were raisins $508,000, prunes $331,000, figs $297,000, dried currants $213,000, bananas $83,000, fresh pineapples $22,000, and grapes $10,000.

Spain supplied the greater part of the citrus fruits and France most of the apples, wines, and olive oil.

*Exports.*—The principal fruits exported from Belgium during the five years 1909–1913 and their average annual value were apples valued at $738,000 and grapes valued at $374,000. Germany was the principal customer for apples and the United Kingdom for grapes.

### NETHERLANDS.

*Area.*—During the five years 1909–1913 the area of the commercial orchards of the Netherlands averaged 52,790 acres annually, as compared with 57,147 acres in 1914.

*Imports.*—The value of imports of fruits into the Netherlands during the five years 1909–1913 averaged $2,020,000 annually. Fresh fruits contributed 70.2 per cent of this value, dried fruits 26.8 per cent, and preserved fruits 3 per cent. In addition, imports of wines averaged $2,102,000 annually and imports of olive oil $35,000 annually.

The principal fruits imported during the period named and their average annual value were oranges and mandarins $723,000, dried fruits $541,000, lemons $111,000, apples $88,000, pears $62,000, canned fruits and grapes $48,000 each, and pineapples $17,000. The chief source of supply for oranges was Spain, for lemons Italy, for dried fruits United States, and for apples, grapes, and pears Belgium.

*Exports.*—During the five years 1909–1913 there was exported from the Netherlands an average of 91,003,000 pounds of fruits annually, valued at $1,705,000. Fresh fruits contributed 84.9 per cent of this value, prepared or preserved fruits 14 per cent, and dried fruits 1.1 per cent. There were also exported during these five years wines to the value of $449,000 annually and olive oil to the value of $47,000.

The principal fruits exported during the five years named and their average annual value were apples $514,000, strawberries $263,000, pears $127,000, cherries $73,000, grapes $44,000, currants $42,000, and dried fruits $18,000.

Germany took 83.4 per cent of the apples exported, practically all of the strawberries, and 76.2 per cent of the pears, while Belgium was the chief customer for wines.

## DENMARK, NORWAY, AND SWEDEN.

### DENMARK.

*Imports.*—General imports of fruits into Denmark for the five years 1909–1913 averaged 56,896,000 pounds annually, valued at $1,875,000. Dried fruits contributed 49.6 per cent of this value, fresh fruits 45 per cent, and prepared or preserved fruits 5.4 per cent. In addition, imports of wines averaged $734,000 annually, and of olive oil $105,000.

The principal fruits imported during the five years named and their average annual value were prunes $340,000, fresh apples $250,000, raisins $226,000, oranges $214,000, prepared or preserved fruits $101,000, bananas $92,000, dried apples $90,000, apricots $84,000, lemons $70,000, grapes $64,000, figs $55,000, pears and dried currants $37,000 each, and plums $28,000.

Prunes and apples were obtained chiefly from the United States, raisins from Spain, oranges and olive oil from Italy, and wine from France.

*Exports.*—Exports of fruit from Denmark during the five years 1909–1913 averaged 412,000 pounds annually, valued at $17,000. Fresh fruits contributed 59 per cent of this value, and prepared or preserved fruits practically all of the remainder.

### NORWAY.

*Imports.*—Imports of fruits into Norway during the five years 1909–1913 averaged 31,839,000 pounds annually, valued at $1,319,000. Fresh fruits contributed 59.4 per cent of this value, dried fruits 38.5 per cent, and preserved fruits 2.1 per cent. In addition, imports of wine averaged $1,129,000 annually, and of olive oil $495,000.

The principal fruits imported into Norway during the five years named and their average annual value were oranges and lemons $326,000, apples and pears $206,000, prunes and dates $201,000, and raisins $177,000.

Apples and pears were obtained chiefly from the United States, prunes and dates from Germany, oranges, raisins, and wines from Spain, and olive oil from France.

*Exports.*—Exports of fruit from Norway during the five years 1909–1913 averaged 1,787,000 pounds annually, valued at $67,000. The greater part of these exports consisted of fresh berries which were shipped principally to the United Kingdom.

### SWEDEN.

*Imports.*—Imports of fruit into Sweden during the five years 1909–1913 averaged 38,566,000 pounds annually, valued at $2,179,000. Fresh fruits contributed 65.1 per cent of this value, dried fruits 33 per cent, and prepared or preserved fruits 1.9 per cent. In addition, imports of wines averaged $1,254,000 annually, and of olive oil $36,500.

The principal fruits imported during the five years named and their average annual value were oranges $443,000, prunes $423,000, fresh apples $294,000, dried apples $187,000, raisins $216,000, grapes $88,000, pears $87,000, bananas $81,000, preserved fruit $69,000, lemons $61,000, and figs $56,000.

Oranges were imported chiefly from Italy and Germany, prunes and dried apples from the United States, raisins from Spain, fresh apples from Great Britain, and wine from France.

*Exports.*—Exports of fruit from Sweden during the five years 1909–1913 averaged 10,406,000 pounds annually, valued at $330,000. Red whortleberries, shipped chiefly to Germany, comprised practically all of these exports.

## FRANCE.

### AREA AND PRODUCTION.

The cultivation of the vine is the most important fruit industry of France. During the 10 years 1904–1913, the area devoted to the growing of wine grapes showed a gradual reduction from 4,262,000 acres in 1904 to 3,830,000 acres in 1913, averaging 4,036,000 acres for the whole period. From the grapes grown on this area there was obtained a yearly average of 1,408,000,000 gallons of wine, valued at $224,534,000. In 1914 the area under wine grapes amounted to 3,803,000 acres and the production of wine to 1,585,000,000 gallons, valued at $211,402,000.

Statistics with reference to the production of table grapes are not available for years prior to 1911. During the three years 1911–1913, however, table grapes to the extent of 71,000 short tons a year, valued at $4,576,000, were grown on an area averaging 47,000 acres, as compared with 89,000 short tons, valued at $9,223,000, produced from 80,000 acres in 1914.

Statistics of the principal orchard fruits are shown in the following table:

TABLE 7.—*Production of orchard fruits in France for the 10-year period 1904–1913, together with comparative figures for 1914 and 1915.*

| Name of fruit. | Quantity (in tons of 2,000 pounds). | | |
|---|---|---|---|
| | Average, 1904–1913 | 1914 | 1915 |
| Olives | 87,782 | 90,983 | 42,719 |
| Peaches | 31,967 | 22,042 | 15,027 |
| Apricots | 7,336 | 9,402 | 7,800 |
| Apples and pears for table use | 171,650 | 204,250 | 297,601 |
| Apples and pears for cider | 2,782,593 | 2,673,534 | 4,940,913 |
| Cherries | 33,797 | 43,575 | 42,860 |
| Plums | 43,609 | 27,659 | 28,654 |
| Plums for prunes | 32,853 | 14,138 | 17,921 |

Expressed in terms of bushels of 48 pounds, there was produced during the 10 years 1904–1913 an annual average of 1,332,000 bushels of peaches, 7,152,000 bushels of apples and pears for table use, and 115,941,000 bushels of apples and pears for cider. The production of cider and perry averaged 434,142,000 gallons annually, ranging between 72,000,000 gallons in 1907 and 960,000,000 gallons in 1904. In 1915 there were produced 626,000 bushels of peaches, 12,400,000 bushels of apples and pears for table use, 206,000,000 bushels of apples and pears for cider, and 606,000,000 gallons of cider and perry. Statistics of the production of apples for table use were stated separately in 1915 when the production was given as 455,000,000 pounds, equivalent to 9,478,000 bushels of 48 pounds.

### IMPORTS.

Imports of fruit into France during the five years 1909–1913 averaged 420,450,000 pounds annually, valued at $9,958,000. Fresh fruits contributed 63.8 per cent of this value, dried fruits 32.7 per cent, and prepared or preserved fruits 3.5 per cent. In addition, there was imported an annual average of 215,000,000 gallons of wine, valued at $51,000,000, and 38,480,000 pounds of olive oil, valued at $4,938,000.

The principal fruits imported during the five years 1909–1913 were lemons, oranges, and raisins. Imports of lemons and oranges averaged 218,000,000 pounds annually, valued at $2,890,000, and of raisins 17,540,000 pounds, valued at $1,044,000. Of the other fruits imported, the more important and their average annual value were figs $852,000, bananas $829,000, prunes $717,000, grapes for table use $508,000, mandarins $431,000, dried apples and pears for cider and perry $150,000, and preserved pineapples $111,000.

Lemons and oranges were imported chiefly from Spain, raisins from Turkey, olive oil from Tunis, and wine from Algeria.

### EXPORTS.

Exports of fruits from France during the five years 1909–1913 averaged 403,138,000 pounds annually, valued at $8,957,000. Fresh fruits contributed 69.7 per cent of this value, dried fruits 19.7 per cent, and preserved fruits 10.6 per cent. In addition, exports of wines averaged 52,094,000 gallons annually, valued at $41,586,000, and of olive oil 11,898,000 pounds annually, valued at $1,461,000.

The principal fruits exported during the five years named were apples, pears, and prunes. Exports of apples and pears for table use averaged 61,151,000 pounds annually, valued at $1,718,000; of apples and pears for cider and perry 177,920,000 pounds annually, valued at $890,000; and of prunes 21,512,000 pounds annually, valued at $1,514,000.

Other important fruits exported and their average annual value were sugared fruits $749,000, table grapes $689,000, and wine grapes $358,000.

Apples and pears for table use were shipped principally to Belgium and the United Kingdom, and for cider and perry to Germany, prunes to the United Kingdom, wines to Belgium, the United Kingdom, and Germany, and olive oil to the United States, Belgium, and the United Kingdom.

## GERMANY.

### ORCHARD FRUITS.

The number of fruit trees in Germany in 1900 with comparative figures for the year 1913 is shown in the following table. Statistics of production are not given.

TABLE 8.—*Number of fruit trees in Germany, 1900 and 1913.*

| Kind of tree. | 1900 | 1913 | | |
|---|---|---|---|---|
| | | Bearing. | Nonbearing. | Total. |
| | *Number.* | *Number.* | *Number.* | *Number.* |
| Apple | 52,332,853 | 49,744,082 | 24,631,847 | 74,375,929 |
| Pear | 25,116 266 | 22,200,657 | 8,588,229 | 30,788,886 |
| Plum | 69,436,083 | 52,673,330 | 11,873,887 | 64,547,217 |
| Cherry | 21,548,024 | 16,218,848 | 5,171,240 | 21,390,088 |
| Apricot | (1) | 511,679 | 258,052 | 769,731 |
| Peach | (1) | 1,285,447 | 735,741 | 2,021,188 |

[1] No data.

### VINEYARDS.

The area of vineyards harvested, and production and value of must, during the five years 1909–1913, are shown in the following table. Data concerning grapes intended for table use are not recorded, an earlier inquiry having shown that the quantities thus consumed are inconsiderable:

TABLE 9.—*Area and production of vineyards in Germany, 1909–1913.*

| Year. | Area harvested. | Must produced. | Value of must. |
|---|---|---|---|
| | *Acres.* | *Gallons.* | *Dollars.* |
| 1909 | 283,515 | 53,378,719 | 17,436,240 |
| 1910 | 278,002 | 22,352,454 | 13,887,060 |
| 1911 | 271,941 | 77,213,879 | 42,471,060 |
| 1912 | 268,944 | 53,346,478 | 22,486,080 |
| 1913 | 261,620 | 26,547,685 | 11,528,880 |

### IMPORTS.

The value of imports of fruits into Germany for home consumption during the five years 1909–1913 averaged $41,485,000 annually, mounting steadily from $35,000,000 in the first-named year to $53,000,000 in the last named. Fresh fruits contributed 66.7 per cent of the total value, dried fruits 31.1 per cent, and preserved fruits 2.2 per cent. In addition, there were imported annually 1,277,000 bottles of sparkling wine, valued at $1,741,000, 282,000,000 pounds of wines other than sparkling, valued at $13,575,000, 6,320,000 pounds of olive oil for table use, valued at $916,000, and 7,618,000 pounds of olive oil for industrial uses, valued at $491,000.

The principal fruits imported into Germany during the five years 1909–1913 were fresh apples 560,275,000 pounds annually, valued at $7,502,000; dried apples 27,355,000 pounds, valued at $2,157,000; grapes 169,016,000 pounds, valued at $5,633,000; oranges and mandarins 288,117,000 pounds, valued at $4,899,000; prunes 73,290,000 pounds, valued at $4,044,000; raisins 39,990,000 pounds, valued at $2,478,000; bananas 66,719,000 pounds, valued at $1,894,000; fresh pears and quinces 100,678,000 pounds, valued at $1,847,000; fresh lemons, dates, figs, etc., 80,732,000 pounds, valued at $1,827,000; fresh berries 50,704,000 pounds, valued at $1,697,000; dried currants 36,342,000 pounds, valued at $1,664,000; and fresh plums 60,438,000 pounds, valued at $1,095,000. Of the other fruits imported during the five years named the more important and their average annual value were dried figs $803,000, fresh cherries $798,000, dried peaches and apricots $748,000, fresh and preserved pineapples $662,000, fresh peaches $485,000 and preserved fruits $436,000.

Dried apples, dried peaches and apricots, and prunes were imported chiefly from the United States; fresh apples and wines from France; fresh pears, quinces, and plums from Austria-Hungary; cherries, grapes, lemons, peaches, and olive oil from Italy; bananas and oranges from Spain; fresh berries from the Netherlands; dried currants from Greece; dried figs and raisins from Turkey; pineapples from Portugal; and preserved fruit from Serbia.

### EXPORTS.

Exports of fruits from Germany during the five years 1909–1913 averaged 41,353,000 pounds annually, valued at $1,216,000. Fresh fruits contributed 80.3 per cent of this value, dried fruits 16.5 per cent, and preserved fruits 3.2 per cent. There were also exported wines to the value of $5,627,000 annually. Fifteen per cent of the value of wine exports was derived from sparkling wines and 85 per cent from wines other than sparkling.

The principal fruits exported from Germany during the five years 1909–1913 and their average annual value were fresh plums $275,000, berries (not including strawberries) $242,000, pears and quinces $197,000, apples $121,000, and cherries $98,000.

Fresh fruits are exported principally to the United Kingdom, dried fruits to Sweden, France, and Finland, sparkling wines to the United Kingdom, and other wines to the United States and the United Kingdom.

## ITALY.

### PRODUCTION OF CITRUS FRUITS.

The latest estimates of the area under citrus fruits give it as 111,000 acres especially devoted to their cultivation and 154,000 acres under mixed crop. Of the area especially devoted to the cultivation of citrus fruits 99.7 per cent is located in six departments, namely, Sicily 70.9 per cent, Calabria 18.7 per cent, Campania 6.9 per cent, Apulia 1.4 per cent, Sardinia 1.2 per cent, and Liguria 0.6 per cent.

The annual production of all citrus fruits in Italy for the five years 1909–1913 averaged 867,000 tons, as compared with 966,000 tons in 1913, 884,000 tons in 1914, and 893,000 tons in 1915. The six departments named above contributed 99.8 per cent of the total production for the five years 1909–1913, and 99.7 per cent for each of the three years 1913–1915. Sicily produced 70.6 per cent of all the citrus fruits grown in Italy during the five years named, Calabria 13.5 per cent, and Campania 9.1 per cent. In 1914 and 1915 the proportion produced by Sicily was 72.2 per cent and 74.1 per cent, respectively.

Statistics of production of the various kinds of citrus fruits are not given for all Italy. For the years 1913 and 1914, however, data concerning the production of lemons, oranges, and mandarins are given for the six leading departments already mentioned. The total combined production of the fruits specified in these six departments was 962,000 tons in 1913 and 878,000 tons in 1914.

*Lemons.*—The production of lemons was 474,000 tons in 1913 and 471,000 tons in 1914. Expressed in terms of boxes containing 75 pounds of fruit, the production of lemons in these two years was equivalent to 12,651,000 boxes and 12,549,000 boxes, respectively. Sicily produced 84 per cent of the lemons in 1913 and 86.6 per cent in 1914, Campania 5.2 per cent and 6.3 per cent, respectively, and Calabria 6.4 per cent, and 3.3 per cent, respectively.

*Oranges.*—The production of oranges was 453,000 tons in 1913 and 378,000 tons in 1914. On the basis of 64 pounds of fruit to a box, the production of oranges in these two years was equivalent to 14,165,000 boxes and 11,798,000 boxes, respectively. Sicily produced 61 per cent of the oranges in 1913 and 57.2 per cent in 1914, Calabria 19.3 per cent and 18.9 per cent, respectively, and Campania 14.4 per cent and 17.9 per cent, respectively.

*Mandarins.*—The production of mandarins was 35,000 tons in 1913 and 30,000 tons in 1914. Slightly more than one-half of the mandarin crop was grown in Sicily.

### VINEYARDS.

The area under vines in Italy during the five years 1910–1914 averaged 10,907,000 acres annually. Of this area 2,195,000 acres were especially devoted to the growing of grapes and in the case of the remaining 8,712,000 acres, other crops were grown on the same ground. In 1915 the area under pure crop was 2,157,000 acres and under mixed crop 8,756,000 acres.

The production of grapes for the five years 1909–1913 averaged 7,823,000 tons as compared with 7,495,000 tons in 1914 and 3,320,000 in 1915.

The production of wine for the five years 1909–1913 averaged 1,216,000,000 gallons annually, ranging between 1,632,000,000 gallons in 1909 and 774,000,000 gallons in the year following. In 1914 the vintage amounted to 1,137,000,000 gallons and in 1915 to 503,000,000 gallons.

### OLIVES.

The olive groves of Italy during the three years 1911–1913 covered an average area of 5,723,000 acres, of which 1,353,000 acres were under pure crop and 4,370,000 acres under mixed crop. In 1914 the area under olive trees was 5,678,000 acres. The production of olives averaged 1,187,000 tons annually, as compared with 1,188,000 tons in 1914 and 1,026,000 tons in 1915.

The production of olive oil averaged 47,913,000 gallons annually, ranging between 25,000,000 gallons in 1912 and 68,000,000 gallons in 1909. In 1914 there were produced 47,128,000 gallons of olive oil.

### OTHER FRUITS.

*Apples, pears, quinces, and pomegranates.*—These fruits are bulked together in the statistics of production. During the five years 1909–1913 their average annual production was 250,000 tons, as compared with 266,000 tons in 1914, and 356,000 tons in 1915.

*Dried figs and prunes.*—The production of dried figs and prunes in Italy averaged 87,000 tons annually, as compared with 77,000 tons in 1914 and 107,000 tons in 1915.

*Pulpous fruits.*—The production of pulpous fruits, such as peaches, apricots, cherries, etc., during the five years 1909–1913 averaged 117,000 tons annually, as compared with 126,000 tons in 1914 and 130,000 tons in 1915.

### EXPORTS.

Exports of fruits from Italy during the five years 1909–1913 averaged 1,205,743,000 pounds annually, valued at $21,492,000. Fresh fruits contributed 90 per cent of this value, dried fruits 6.5 per cent, and preserved fruits 3.5 per cent.

Exports of citrus fruits during this period averaged 857 million pounds annually.

The principal fruits exported during the five years 1909–1913 were lemons 588,522,000 pounds annually, valued at $7,207,000; apples and pears 161,781,000 pounds, valued at $4,203,000; oranges 264,667,000 pounds, valued at $3,785,000; table grapes 47,655,000 pounds, valued at $1,426,000; and dried figs 40,956,000 pounds, valued at $1,273,000. Of the other fruits exported, the more important and their average annual value were candied fruit $756,000, peaches $559,000, cherries $439,000, wine grapes $287,000, limes and cedrates $139,000, and apricots $117,000. The chief customer for lemons was the United States; for apples, pears, and grapes, Germany; and for oranges and dried figs, Austria-Hungary.

In addition to fruits, fruit products constitute an important item of export. The principal fruit products exported from Italy during the five years 1909–1913 were the following: Wines to the value of $10,468,000 annually; olive oil for table use 54,780,000 pounds annually, valued at $8,558,000; olive oil for industrial uses 20,350,000 pounds, valued at $1,482,000; citrate of lime 12,447,000 pounds, valued at $1,733,000; and essential oil of lemon 1,009,000 pounds annually, valued at $1,414,000. Wines were shipped chiefly to Switzerland, Argentina, and Brazil; olive oil for table use to the United States, Argentina, and France; olive oil for industrial uses to the United States, Egypt, and Austria-Hungary; citrate of lime to the United States, the United Kingdom, and France; and essential oil of lemon to the United States and the United Kingdom. Other fruit products of importance exported and their average annual value were essential oil of bergamot $633,000, essential oil of orange $371,000, essential oil of mandarin $5,903, citrus fruit peel $137,000, concentrated citrus fruit juices $56,000, and raw citrus fruit juices $21,000.

### IMPORTS.

Imports of fruits into Italy during the five years 1909–1913 averaged 20,528,000 pounds annually, valued at $927,000. These imports do not include fruits listed with vegetables. Two-thirds of the total value of fruits imported consisted of dried fruits and the remainder of fresh fruits. In addition, imports of olive oil for table use averaged $991,000 annually and of wine $599,000.

The principal fruits imported during the five years 1909–1913 and their average annual value were dates $305,000, bananas $185,000, raisins $153,000, prunes $139,000, and limes and cedrates $93,000.

Olive oil was imported chiefly from Spain, wines from France, dates from Tunis, bananas from Spanish Africa, raisins from Turkey, and prunes from the United States.

## RUSSIA.

### PRODUCTION.

Fruit is cultivated extensively throughout the Russian Empire, but no official estimates of production are available, except for grapes. Statistics of the vintage of 1910 are shown in the following table:

**Table 10.**—*Area of vineyards and production of grapes and must in Russia in 1910.*

| District. | Area. | Production of grapes. | Production of must. |
|---|---|---|---|
| | *Acres.* | *Pounds.* | *Gallons.* |
| European Russia | 303,183 | 426,105,761 | 21,348,085 |
| Northern Caucasia | 53,264 | 258,878,218 | 14,597,857 |
| Transcaucasia | 229,168 | 488,700,077 | 22,880,487 |
| Turkestan | 80,468 | 84,153,658 | 175,885 |
| Total | 666,083 | 1,257,837,714 | 59,002,314 |

The home market for fresh apples, pears, peaches, cherries, plums, and apricots is supplied practically entirely by Russian fruit growers, oranges and lemons being the only fruits imported in large quantities. These latter fruits, together with olives, are grown in the Caucasus, especially near the Black Sea, but not in sufficient quantity to supply domestic needs.

### IMPORTS.

The value of fruits imported into Russia during the five years 1909–1913 averaged $10,952,000 annually. Fresh fruits contributed 49.7 per cent of this value, dried fruits 46.6 per cent, and prepared or preserved fruits 3.7 per cent. In addition, annual imports of wine averaged $6,146,000 and of olive oil $1,459,000.

The principal fruits imported into Russia during the period named were the following: Raisins, 69,857,000 pounds annually, valued at $2,977,000; oranges, 117,826,000 pounds, valued at $2,345,000; and lemons, 92,913,000 pounds, valued at $1,609,000. Of the remaining fruits imported the more important and their average annual value were prunes, $477,000; fresh apples, pears, peaches, cherries, plums, and apricots, $439,000; dried figs, $379,000; olives, $336,000; dates, $291,000; grapes, $234,000; fresh berries, $28,000; canned berries and other fruits, $20,000; and dried currants, $15,000.

Raisins and dates were obtained chiefly from Persia, oranges and lemons from Italy, deciduous tree fruits from Japan and Germany, olive oil from Germany, and wines from France and Germany.

### EXPORTS.

The value of exports of fruits from Russia during the five years 1909–1913 averaged $1,260,000 annually. Fresh and preserved fruits contributed two-thirds of this value, and dried fruits the remainder. In addition, exports of wine averaged $86,000 annually.

The chief fruits exported during the period named were raisins, $547,000, fresh huckleberries, $56,000, and dried berries, $21,000. Germany was the principal customer for all of these fruits.

## SOUTHEASTERN EUROPE.

### BULGARIA.

#### Area and Production.

*Orchard fruits.*—The area under orchard fruits in Bulgaria during the three years 1909–1911 averaged 20,475 acres annually, 2,271 acres of which carried trees not of bearing age. The production of orchard fruits averaged 69,325,000 pounds annually, valued at $979,000. Plums are cultivated more extensively than any other orchard fruit, the area planted with plum trees averaging 12,132 acres annually, or approximately three-fifths of the total area under orchard fruits. The production of plums averaged 39,687,000 pounds annually, valued at $441,000. The only other orchard fruit for which statistics of area and production are given separately is the apple, to which only 319 acres were devoted in 1911.

*Vineyards.*—Wine grapes in Bulgaria during the three years 1909–1911 were cultivated on an area averaging 192,000 acres annually, of which 16,173 acres were planted with vines not of bearing age. There was a marked reduction in acreage during the period named, from 211,000 acres in 1909 to 168,000 acres in 1911. The production of grapes averaged 363,924,000 pounds annually and of must 23,251,000 gallons.

#### Imports.

The total value of imports of fruits during the three years 1909–1911 averaged $883,000 annually, declining from $1,506,000 in 1909 to $471,000 in 1911. Fresh fruits contributed 50.8 per cent of the total value of fruit imports, and dried, prepared, or preserved fruits 49.2 per cent. In addition, imports of olive oil averaged $451,000 annually and of wines $28,000.

The principal fruits imported and their average annual value were olives $211,000, citrus fruits $101,000, dates $69,000, grapes $63,000, figs $52,000, raisins $31,000, and prunes $27,000. Turkey supplied the bulk of the fruits and olive oil and France most of the wines.

#### Exports.

The value of exports of fruits from Bulgaria averaged $33,000 annually. Dried, prepared, or preserved fruits contributed 87.5 per cent of this value and fresh fruits 12.5 per cent. Nearly all of the dried fruits, chiefly prunes, were exported to Austria-Hungary, while Turkey took the larger part of the fresh fruits.

## GREECE.

### PRODUCTION.

The principal fruits cultivated in Greece are currant grapes, olives, and figs, and of these the most important is the currant grape. The currant is the dried product of a small European grape, and practically the entire world's supply is grown in Greece. The word "currant" is generally believed to be a corruption of the name "Corinth," the Greek port whence early shipments of this fruit first reached western Europe. From reports of the American consul at Patras it is estimated that the dried currant crop of Greece during the five years 1909–1913 averaged about 155,000 tons annually, ranging between 185,000 tons in 1909 and 123,000 tons in the year following. The crop of 1914 is estimated at 158,000 tons and that of 1915 at 130,000 tons.

### EXPORTS.

Exports of domestic fruits from Greece during the five years 1909–1913 averaged 301,819,000 pounds annually, valued at $9,759,000. Dried fruits contributed 90.8 per cent of this value, prepared or preserved fruits 7.8 per cent, and fresh fruits 1.4 per cent. In addition, exports of wines from Greece averaged 126,613,000 pounds annually, valued at $2,656,000, and of edible olive oil 17,624,000 pounds, valued at $1,677,000.

The principal fruit exported from Greece is the dried currant. During the five years 1909–1913 exports of dried currants from Greece averaged 233,238,000 pounds annually, valued at $7,521,000, or 77.1 per cent of the total value of all fruits exported. The United Kingdom is the principal customer for these currants, exports to that country averaging 52 per cent of the total, as compared with 12.7 per cent to America, 12.6 per cent to the Netherlands, 12.3 per cent to Germany, and 5 per cent to Austria-Hungary. Of the other fruit and fruit products exported during this period the more important and their average annual value were figs $1,007,000, olives $764,000, raisins $318,000, citrus fruits $87,000, grapes $9,949, olive oil for industrial uses $267,000, and must $37,000.

### IMPORTS.

Imports of fruits into Greece during the five years 1909–1913 averaged 1,971,000 pounds annually, valued at $82,000. Fresh fruits contributed 52.9 per cent of this value, dried fruits 41.6 per cent, and prepared or preserved fruits 5.5 per cent. In addition imports of wine during this period averaged $77,000 annually. The principal fruit imported into Greece is dates.

## CRETE.

*Exports.*—Exports of fruit from the Island of Crete during the four years 1909–1912 averaged 27,784,000 pounds annually, valued at $601,000. Dried or preserved fruits contributed 62.8 per cent of this value and fresh fruits 37.2 per cent. In addition, the average annual value of olive oil and wines exported was $1,176,000 and $203,000, respectively.

*Imports.*—Imports of fruits into Crete during the four years 1909–1912 averaged 126,500 pounds annually, valued at $4,600. The largest single item was dried or preserved olives, imported principally from Greece.

## ROUMANIA.

### AREA AND PRODUCTION.

*Orchard fruits.*—The principal orchard fruit grown in Roumania is the plum. During the five years 1909–1913 the area under plum trees averaged 180,000 acres annually, as compared with 193,000 and 173,000 acres, respectively, in 1914 and 1915. The production of plums averaged 308,000,000 pounds annually, valued at $2,505,000, as compared with 365,000,000 pounds in 1914, valued at $3,305,000.

*Vineyards.*—The area devoted to the cultivation of the vine in Roumania during the five years 1909–1913 averaged 216,000 acres annually. American vines resistant to attacks of the phylloxera are rapidly replacing the native vines. From an area of 45,000 acres in 1909, or 21 per cent of the total area in vineyards, the area under American vines increased to 97,000 acres in 1913 and to 113,000 acres, or 55 per cent of the total area, in 1914. The production of wine averaged 37,436,000 gallons annually, valued at $10,493,000, as compared with 17,453,000 gallons in 1914. Of the total production of wine in 1914, 74 per cent was derived from grapes grown on American vines.

### IMPORTS.

Imports of fruits into Roumania during the four years 1909–1912 averaged 48,052,000 pounds annually, valued at $1,183,000. Prepared or preserved fruits contributed 40.7 per cent of this value, fresh fruits 36.6 per cent, and dried fruits 22.7 per cent. In addition, imports of olive oil averaged 7,333,000 pounds annually, valued at $614,000, and of wines 2,381,000 pounds annually, valued at $360,000.

The principal fruits imported during the four years 1909–1912 and their average annual value were olives $446,000, oranges $157,000, raisins $137,000, lemons $115,000, figs $61,000, table grapes $50,000, mandarins $30,000, dried apricots $23,000, and dates $22,000. The citrus fruits were obtained chiefly from Italy and the figs from Greece. The bulk of the remaining fruits, as well as olive oil, was obtained from Turkey. France supplied the larger part of the wine.

### EXPORTS.

Exports of fruits from Roumania during the four years 1909–1912 averaged 1,665,000 pounds annually, valued at $37,000. The principal fruits exported and their average annual value were prunes $36,000, plums $15,000, and pears $6,500.

## SERBIA.

*Area and production.*—Plum growing is the principal fruit industry of Serbia. During the three years 1904–1906 the average area under plum trees was 367,000 acres and the average annual production of plums 987,000,000 pounds, valued at $4,358,000.

The average area under vines was 83,000 acres and the average annual production of wine 11,776,000 gallons, valued at $5,138,000.

Of fruits other than plums and grapes, such as apples, pears, etc., the production averaged 229,000,000 pounds annually, valued at $2,940,000.

*Exports.*—There was exported from Serbia in 1909 a total of 63,000,000 pounds of fruit, valued at $899,000, as compared with 106,000,000 pounds, valued at $2,920,000, in the year following. Of the total value of the fruit exported during these two years 64 per cent was derived from prunes, 16.7 per cent from plum marmalade, 7.5 per cent from apples, 5.8 per cent from pears, and 5.3 per cent from plums. Most of these fruits were shipped to Austria-Hungary. In addition, wine to the value of $25,000 was exported from Serbia in 1910.

*Imports.*—Imports of fruits into Serbia in 1909 amounted to 19,017,000 pounds, valued at $258,000, as compared with 28,098,000 pounds, valued at $518,000, in 1910. The principal fruits imported into Serbia in 1910 and their value were grapes $470,000, citrus fruits $23,000, and figs and dates $11,000. In addition, imports of wine and olive oil in 1910 were valued at $82,000 and $48,000, respectively.

## TURKEY.

*Production.*—The growing of fruit for export, especially in Asiatic Turkey, has long been an important industry of the Turkish Empire. Raisins, figs, oranges, dates, and olives are the chief fruits cultivated.

*Exports.*—Exports of fruits from Turkey during the fiscal year beginning March 4, 1910, amounted to 456,084,000 pounds, valued at $14,315,000, and in 1911 to 518,290,000 pounds, valued at $17,664,000. Of the total value of all fruits exported in these two years dried fruits contributed 79 per cent, fresh fruits 17.4 per cent, and prepared or preserved fruits 3.6 per cent. The principal fruits exported in 1911 were raisins 89,728,000 pounds, valued at $8,423,000; figs 62,422,000 pounds, valued at $2,676,000; citrus fruits 145,353,000 pounds, valued at $2,265,000; dates 153,291,000 pounds, valued at $2,256,000;

olives 24,972,000 pounds, valued at $1,074,000; and dried apricots 1,049,000 pounds, valued at $86,000. There were also exported olive oil and wine to the value of $2,356,000 and $449,000, respectively.

The United Kingdom was the best customer for citrus fruits, figs, and raisins; Egypt for dried apricots; India and the United Kingdom for dates; Roumania for olives and olive oil; and Germany and France for wines.

*Imports.*—Imports of fruits into Turkey during the fiscal year beginning March 14, 1910, amounted to 37,248,000 pounds, valued at $868,000, as compared with 33,079,000 pounds in 1911, valued at $910,000. Of the total value of all fruits imported in these two years 51.8 per cent was contributed by dried fruits, 41.2 per cent by fresh fruits, and 7 per cent by prepared or preserved fruits. The principal fruits imported in 1911 and their value were citrus fruits $273,000; olives, $74,000; raisins, $62,000; dates, $37,000; and figs, $16,000. There were also imported in this year wines to the value of $355,000 and olive oil to the value of $186,000.

## SPAIN AND PORTUGAL.

### SPAIN.

### PRODUCTION.

Statistics of the production of grapes and olives are published annually by the Spanish Government. With regard to other fruits, however, the latest official figures relate to the year 1910.

TABLE 11.—*Production of fruit in Spain in 1910.*

| Fruit. | Acres. | Tons of 2,000 pounds. | Fruit. | Acres. | Tons of 2,000 pounds. |
|---|---|---|---|---|---|
| Apples | 52,066 | 169,029 | Oranges | 117,457 | 876,047 |
| Apricots | 8,466 | 16,795 | Peaches | 13,017 | 21,183 |
| Cherries, sour | 3,598 | 7,025 | Pears | 26,272 | 70,553 |
| Cherries, sweet | 5,770 | 11,450 | Plums | 12,387 | 29,867 |
| Figs | 141,198 | 121,919 | Pomegranates | 8,201 | 23,036 |
| Grapes | 3,194,855 | 2,283,357 | Quinces | 3,833 | 8,657 |
| Lemons | 6,363 | 69,775 | All others | 8,508 | 26,530 |
| Olives | 3,499,237 | 688,517 | | | |

The principal fruits grown in Spain are the following:

*Grapes.*—The area of the vineyards of Spain for the five years 1909–1913 averaged 3,158,000 acres annually, the production of grapes 2,920,000 tons, and the production of must 393,000,000 gallons. It is estimated that 90.8 per cent of the crops of these years was sent to wineries, 2.6 per cent dried for raisins, and 1.9 per cent exported for table use.

The growing of table grapes for export is virtually confined to the Province of Almeria, where an area of 12,000 acres, producing an average of 57,000 tons annually, is devoted to this industry. The

Almeria grape is packed in ground cork and shipped in small barrels containing about 47 pounds of fruit. It is noted for its shipping qualities.

Statistics of grapes for a series of years are shown in the following table:

TABLE 12.—*Production of grapes and must in Spain.*

| Year. | Area. | Production of grapes. | Grapes pressed for wine. | Production of must. |
|---|---|---|---|---|
| | *Acres.* | *Tons of 2,000 pounds.* | *Tons of 2,000 pounds.* | *Gallons.* |
| 1909 | 3,204,506 | 2,963,413 | 2,666,588 | 388,758,040 |
| 1910 | 3,194,855 | 2,283,357 | 2,049,481 | 298,074,450 |
| 1911 | 3,187,533 | 2,972,172 | 2,683,254 | 389,572,846 |
| 1912 | 3,112,573 | 3,125,592 | 2,878,660 | 434,957,226 |
| 1913 | 3,089,145 | 3,254,274 | 2,984,680 | 451,868,148 |
| 1914 | 3,066,820 | 3,086,451 | 2,854,105 | 427,108,471 |
| 1915 | 3,080,163 | 1,840,905 | 1,671,775 | 232,204,902 |

*Olives.*—During the five years 1909–1913 the area of the olive groves of Spain averaged 3,526,000 acres annually, the production of olives 1,341,000 tons, and the production of olive oil 242,000 tons. Of the total production of olives in the five years named, 95.7 per cent was pressed for oil. Light and heavy crops alternate as a rule. Although the cultivation of olives is general throughout Spain, more than one-half the crop is produced in the Provinces of Lerida, Jaen, Seville, and Cordoba. Seville is the center of the pickled-olive industry. Statistics of olives for the years 1909–1914 are shown in the following table:

TABLE 13.—*Production of olives and olive oil in Spain.*

| Year. | Area. | Production of olives. | Olives used for making oil. | Production of olive oil. |
|---|---|---|---|---|
| | *Acres.* | *Tons of 2,000 pounds.* | *Tons of 2,000 pounds.* | *Tons of 2,000 pounds.* |
| 1909 | 3,446,694 | 1,541,339 | 1,468,534 | 264,301 |
| 1910 | 3,499,237 | 688,517 | 667,002 | 119,609 |
| 1911 | 3,567,197 | 2,446,573 | 2,341,112 | 464,931 |
| 1912 | 3,577,123 | 391,681 | 383,170 | 69,446 |
| 1913 | 3,590,086 | 1,638,982 | 1,559,523 | 292,575 |
| 1914 | 3,618,841 | 1,302,291 | 1,259,280 | 229,019 |

*Oranges.*—The orange groves of Spain covered an area of 117,457 acres in 1910, when the production of oranges amounted to 876,000 tons, equivalent to 27,376,000 boxes, averaging 64 pounds of fruit to the box. Six Provinces reported 92.8 per cent of the area, namely, Valencia, 42.1 per cent; Castellon, 32.2 per cent; Tarragona, 6.9 per cent; Murcia, 5 per cent; Seville, 3.5 per cent; and Alicante, 3.1 per cent. Three-fourths of the area under orange trees is situated in the Valencia district, which comprises a narrow strip of land extending for 150 miles along the Mediterranean coast line of the Provinces of Valencia and Castellon. The average yearly production of oranges in this district is estimated at from 400,000 to 450,000 tons. Nearly all of these oranges are exported by sea to northern Europe. The Valencia is the only variety grown extensively in this district, though small quantities of other varieties are also cultivated.

Seville is noted for its bitter oranges. Both sweet and bitter oranges are grown in Seville, but the bitter is the more important commercially. The 1914 crop of this district was estimated at 25,000,000 sweet oranges and 66,000,000 bitter, as compared with 30,000,000 sweet and 70,000,000 bitter in 1913. Most of the bitter oranges are shipped to the United Kingdom, where they are prized for their superior qualities in marmalade manufacture.

*Lemons.*—The area devoted to the cultivation of lemons in 1910 amounted to 6,363 acres, which gave a yield of 69,775 tons, or the equivalent of 1,861,000 boxes averaging 75 pounds of fruit. Four Provinces reported 85 per cent of the total area under lemon trees and 94 per cent of the lemon production. They were Murcia, Valencia, Tarragona, and Malaga.

*Apples.*—The greater part of the apple crop of 1910 was produced in the northern Provinces of Spain. Taking as a basis 48 pounds of apples to the bushel, the crop of 1910 was equivalent to 7,043,000 bushels.

*Figs.*—Of a total production of 122,000 tons of figs, 38.5 per cent was produced in the Balearic Islands and 11.6 per cent in the Province of Murcia.

### EXPORTS.

Exports of fruits from Spain during the five years 1909–1913 averaged 1,401,816,000 pounds annually, valued at $21,353,000. Fresh fruits contributed 80.4 per cent of this value, dried fruits 13.5 per cent, and prepared or preserved fruits 6.1 per cent. In 1914 there were exported 1,261 million pounds of fruits, valued at $18,879,000. In addition to fruits there was exported during the five years 1909–1913 an annual average of 82,056,000 gallons of wine, valued at $19,932,000, and 86,454,000 pounds of olive oil, valued at $7,569,000. Wines were shipped principally to France and olive oil to Italy and Argentina.

The chief fruits exported from Spain during the five years named were oranges, table grapes, raisins, and olives.

*Oranges.*—Spain ranks first in the exportation of oranges. More than one-half of the total value of all fruits exported from Spain is derived from this product alone. During the five years 1909–1913 exports of oranges averaged 1,120 million pounds annually, valued at $11,762,000, the quantities exported ranging between 974 million pounds in 1911 and 1,255 million pounds in 1913. On the basis of 64 pounds of fruit to a box the average yearly exportation of oranges was equivalent to 17,494,000 boxes. Shipments of oranges to the United Kingdom averaged 46.5 per cent of the total quantity exported during the five years named, as compared with 21.2 per cent to France and 18.7 per cent to Germany. In 1914 there was exported a total of 1,054 million pounds of oranges, valued at $11,068,000.

*Grapes for table use.*—Exports of table grapes averaged 97,819,000 pounds annually, valued at $2,997,000, the quantity exported fluctuating between 82 million pounds in 1912 and 122 million pounds in 1913. The principal customers for these grapes were the United Kingdom with 47 million pounds annually, United States 32 million pounds, and Germany 12 million pounds. Most of the grapes are shipped from the port of Almeria. In 1914 there was exported a total of 81,776,000 pounds, valued at $2,506,000.

*Raisins.*—Exports of raisins averaged 52,851,000 pounds annually, valued at $2,545,000, as compared with 34 million pounds in 1914, valued at $1,615,000. More than half of the raisins exported went to the United Kingdom.

*Olives.*—Exports of green and pickled olives from Spain averaged 29,879,000 pounds annually, valued at $1,962,000. More than three-fifths of these olives were shipped to the United States. The next largest customers were Argentina and Cuba.

*Other fruits.*—Of the other fruits exported the more important and their average annual value were pressed grapes $492,000, preserved fruits $431,000, fruit pulp $291,000, dried figs $268,000, lemons $192,000, pomegranates $102,000, apples $32,000, and peaches $23,000.

### IMPORTS.

Imports of fruits into Spain, consisting wholly of dried fruits, averaged 6,237,000 pounds annually, valued at $420,000, during the five years 1909–1913, as compared with 9,054,000 pounds, valued at $603,000, in 1914. Figs and dates were the principal fruits imported. In addition, imports of wines, chiefly from France, averaged 76,000 gallons annually, valued at $242,000.

## PORTUGAL.

### EXPORTS.

The value of exports of fruits from Portugal during the five years 1909–1913 averaged $1,003,000 annually. Fresh fruits contributed 74.1 per cent of this value, prepared or preserved fruits 21.4 per cent, and dried fruits 4.5 per cent. In addition, exports of wines averaged 28,582,000 gallons annually, valued at $12,604,000, and of olive oil 754,000 gallons annually, valued at $681,000.

The principal fruits exported during the five years named and their average annual value were pineapples $383,000, grapes $238,000, figs $196,000, apples $99,000, olives $40,000, and oranges $4,000.

The United Kingdom was the chief customer for apples, grapes, oranges, pineapples, and port wine; Belgium for figs; and Brazil for olives, olive oil, and common red wine.

### IMPORTS.

Imports of fruit into Portugal during the five years 1909–1913 averaged 466,000 pounds annually, valued at $45,000. Spain supplied the greater part of these fruits.

## UNITED KINGDOM.

### AREA.

The area under fruits in the United Kingdom (excluding the Isle of Man and the Channel Islands) during the five years 1909–1913 averaged 321,000 acres annually, as compared with 314,000 acres in 1914. This average area includes 29,000 acres of small fruit grown in orchards. Ninety-three per cent of the fruit acreage was in England, 4.4 per cent in Ireland, and 2.6 per cent in Scotland. Apples, pears, cherries, and plums are the principal orchard fruits grown, and strawberries, raspberries, currants, and gooseberries the principal small fruits. Statistics of production are not collected. The five-year (1909–1913) average acreage under individual fruits was as follows: Apples 175,084, pears 10,153, cherries 11,842, plums 17,441, strawberries 26,804, raspberries 9,461, and currants and gooseberries 28,168.

### IMPORTS.

The value of foreign and colonial fruits entering the ports of the United Kingdom during the five years 1909–1913 averaged $69,827,000 annually, ranging steadily upward from $64,000,000 in the first-named year to $74,000,000 in the last named. Fresh fruits contributed 65.1 per cent of this value, dried fruits 26.2 per cent, and preserved fruits 8.7 per cent. In addition, the annual value of the two leading fruit products imported, wine and olive oil, averaged $19,973,000 and $2,926,000, respectively. The value comprises cost of the fruit plus insurance and freight to the place of landing, or, when consigned for sale, the latest sale value. The weight of the fresh fruit imported (excluding bananas, the weight of which is not given) averaged 1,368 million pounds annually, as compared with 313 million pounds of dried fruits and 113 million pounds of prepared or preserved fruits. The principal fruits imported during the five years named and their average annual quantity and value were oranges 5,662,000 hundredweight of 112 pounds each, valued at $11,678,000; fresh apples 3,369,000 hundredweight, valued at $10,869,000; bananas 6,713,000 bunches, valued at $9,174,000; dried currants 1,247,000 hundredweight, valued at $7,622,000; raisins 721,000 hundredweight, valued at $6,055,000; canned or bottled fruits, including canned pineapples, 715,000 hundredweight, valued at $4,787,000; grapes 613,000 hundredweight, valued at $3,353,000; pears 598,000 hundredweight, valued at $2,701,000; lemons, limes, and citrons 859,000 hundredweight, valued at $2,228,000; fresh plums 386,000 hundredweight, valued at $1,992,000; prunes and other dried plums 187,000 hundredweight, valued at $1,724,000; canned pineapple (1913 only) 270,000 hundredweight, valued at $1,578,000; dates 429,000 hundredweight, valued at $1,466,000; preserved fruits other than canned or bottled 296,000 hundredweight, valued at $1,322,000; and figs and fig cake 179,000 hundredweight, valued at $1,155,000. Other important fruits imported and their average annual value were cherries $793,000, currants $668,000, apricots and peaches $211,000, strawberries $163,000, and gooseberries $74,000.

Of the fruit products imported, the more important, next to wines and olive oil, and their average annual value, were lime and lemon juice, $386,000; grape juice or must, $53,000, and cider and perry, $37,000.

Oranges and grapes were obtained chiefly from Spain; apples from Canada and the United States; bananas from Colombia, Costa Rica, and the Canary Islands; dried currants from Greece; dates, raisins, and figs from Asiatic Turkey; canned fruits and prunes from the United States; pears from Belgium and France; plums, cherries, apricots, peaches, currants, strawberries, and wines from France; lemons from Italy; and edible olive oil from Italy, France, and Spain.

### EXPORTS.

Exports of domestic fruits from the United Kingdom are limited to prepared or preserved fruits. During the five years 1909–1913, exports of this class of products averaged $1,996,000 annually. Marmalades, jams, and fruit jellies comprised the bulk of the fruit exported. Canada ranked first as a customer for these products, United States second, and British India third.

### REEXPORTS.

Reexports of fruits from the United Kingdom during the five years 1909–1913 averaged $4,615,000 annually. Fresh fruits contributed 66.7 per cent of this value, dried fruits 23.5 per cent, and prepared or preserved fruits 9.8 per cent. In addition, reexports of olive oil averaged $390,000 annually, and of wines $2,348,000.

The principal fruits reexported and their average annual value were bananas, $1,005,000, apples $689,000, grapes $625,000, dates $568,000, oranges $495,000, raisins $187,000, and dried currants $132,000.

# ASIA.

## JAPAN.

### PRODUCTION.

The principal fruit grown in Japan is the orange. During the five-year period, 1909–1913, the total number of orange trees in Japan averaged 20,310,000 annually, and the production of oranges 501,000,000 pounds.

TABLE 14.—*Number of fruit trees and production of fruit in Japan.*

| Kind of fruit. | Five-year average, 1909–1913. | | 1914 | |
|---|---|---|---|---|
| | Trees. | Production. | Trees. | Production. |
| | *Number.* | *Pounds.* | *Number.* | *Pounds.* |
| Apples | 2,640,028 | 78,915,023 | 3,257,934 | 78,847,406 |
| Cherries | 104,370 | 1,792,000 | 157,563 | 2,560,102 |
| Figs | 253,140 | 6,104,187 | 325,637 | 7,107,431 |
| Grapes | [1] 2,308,104 | 28,756,922 | [1] 2,800,465 | 32,696,179 |
| Loquats | 1,065,122 | 20,009,002 | 1,205,103 | 20,967,088 |
| Oranges: | | | | |
| Mikan | 13,007,348 | 320,386,159 | 15,806,932 | 330,128,889 |
| Navel | 1,026,630 | 11,522,538 | 1,495,100 | 17,160,658 |
| Natsumikan | 3,271,000 | 100,241,558 | 3,674,582 | 106,073,047 |
| Other | 3,004,621 | 69,213,960 | 3,361,692 | 68,141,831 |
| Peaches | 6,327,817 | 82,988,064 | 7,119,255 | 86,502,959 |
| Pears | 6,950,104 | 157,080,702 | 8,046,157 | 167,125,710 |
| Persimmons: | | | | |
| Green | 9,750,240 | 365,071,466 | 10,569,724 | 321,690,762 |
| Dried | | 41,514,316 | | 30,650,701 |
| Plums | 4,598,537 | [2] 2,468,887 | 4,489,256 | [2] 2,231,930 |
| Quinces | 82,724 | 1,468,286 | 92,318 | 1,551,227 |

[1] Vines.

[2] Bushels.

### EXPORTS.

The chief fruits exported during the five years 1909–1913 were mandarins and apples. Shipments of mandarins averaged 24,729,000 pounds annually, valued at $460,000, and those of apples 8,485,000 pounds, valued at $243,000 Four-fifths of the apples and a large part of the mandarins were exported to Asiatic Russia.

#### IMPORTS.

Imports of fruits into Japan are not classified separately in trade statistics, but are included with nuts and vegetables. Wine is the principal fruit product imported. During the five years 1909–1913 there was imported an annual average of 454,000 gallons of wine, valued at $267,000. Spain and France supplied three-fourths of the wine.

### PERSIA.

#### PRODUCTION.

The growing of fruit for export, especially in its dried form, is an important industry. Among the fruits cultivated are quinces, peaches, apricots, plums, grapes, dates, and oranges.

#### EXPORTS.

During the five years 1909–1913 exports of fruits from Persia averaged 121,000,000 pounds annually, valued at $7,025,000. Fresh and dried fruits contributed 99.9 per cent of this value. The most important fruit exported is the raisin. During the five years 1909–1913 there was exported an annual average of 70,252,000 pounds of raisins, valued at $4,727,000, the quantity exported ranging between 56,000,000 pounds in 1912 and 82,000,000 pounds in 1910. Russia took nearly all of these raisins. Of the other fruits exported during this period the more important items were fresh and dried fruits, not specified, $1,613,000; dates $616,000; citrus fruits $62,000; and preserved fruits $7,000.

## AFRICA.

### ALGERIA.

#### PRODUCTION.

Statistics of grapes and olives are more complete than of the other fruits in Algeria. The area under vines during the five years 1909–1913 averaged 391,000 acres annually, and the production of wine 212,000,000 gallons. Red wine comprised 88.1 per cent of the total production, and white wine 11.9 per cent. The number of olive trees averaged 13,081,000 annually during this period, the production of olives 599,000,000 pounds, and the production of olive oil 8,421,000 gallons. Data concerning other fruits cultivated are given in the following table:

TABLE 15.—*Number of fruit trees in Algeria.*

| Kind of fruit tree or plant. | 4-year average, 1909–1912. | | 1912. | |
|---|---|---|---|---|
| | Total number. | Number bearing. | Total number. | Number bearing. |
| Banana | 52,286 | 34,624 | 42,890 | 31,303 |
| Cherry | 87,328 | 73,147 | 100,787 | 82,627 |
| Citrus: | | | | |
| Lemon and cedrate | 175,322 | 150,648 | 164,721 | 141,695 |
| Mandarin | 516,406 | 423,674 | 539,373 | 373,264 |
| Orange | 852,166 | 720,822 | 889,832 | 783,341 |
| Date | 3,863,550 | 2,657,756 | 4,131,753 | 3,084,869 |
| Fig | 5,832,220 | 4,860,036 | 6,064,105 | 5,263,398 |
| Medlar | 68,278 | 54,812 | 78,089 | 58,962 |
| Pomegranate | 637,207 | 550,818 | 652,379 | 570,367 |

#### EXPORTS.

The principal fruits exported from Algeria during the five years 1909–1913 and their average annual value, were lemons and oranges $172,000, mandarins, etc., $449,000, grapes $578,000, dates $613,000, and figs $646,000. In addition, shipments of common wines in casks during this period averaged 185,422,000 gallons annually, valued at $33,278,000, and of olive oil 11,918,000 pounds, valued at $1,547,000. Practically all of the fruits and olive oil and 98.5 per cent of the wine were shipped to France.

#### IMPORTS.

Preserved fruits, apples, pears, and raisins were the chief fruits imported into Algeria, and wine and olive oil the chief fruit products.

### BRITISH SOUTH AFRICA.

*Exports.*—The value of fresh fruits exported from the South African Union in 1914 was $453,000. The chief fruits exported and their value were pears $121,000, grapes $100,000, oranges $87,000, plums $49,000, peaches $44,000, pineapples $12,000, nectarines $6,550, apples $6,229, bananas $3,815, and apricots $1,475.

*Imports.*—The principal fruits imported in 1914 were dried currants and raisins $105,000, bottled and canned fruits $57,000, dates $46,000, dried fruits not specified $37,000, and figs $13,000.

### TUNIS.

A wide variety of fruits is cultivated in Tunis, including apples, peaches, apricots, nectarines, pears, plums, cherries, grapes, lemons, mandarins, oranges, dates, olives, and figs. The most important are the olive and the wine grape. In 1912 there were exported 32,793,000 pounds of olive oil, valued at $3,966,000, and 5,684,000 gallons of wine, valued at $1,101,000.

## OCEANIA.

### AUSTRALIA.

#### PRODUCTION.

The total area of the vineyards of Australia increased from 59,450 acres in 1908–09 to 62,388 in 1912–13. The vine is cultivated in all the States of the Commonwealth except Tasmania, where the climatic conditions are unfavorable. During the five seasons 1908–09 to 1912–13 there was produced an annual average of 5,413,000 gallons of wine, 13,480 tons of table grapes, 13,506,000 pounds of raisins, and 8,076,000 pounds of dried currants. South Australia led in the production of wine, New South Wales in the production of table grapes, and Victoria in the production of raisins.

The total area of the orchards and fruit gardens of Australia increased from 171,558 acres in 1908–09 to 205,174 acres in 1912–13. There were increased areas in Tasmania and Western Australia, mainly due to extensive plantings of apple trees with a view to the possibilities of the London market for fresh fruit. The production of fruits in the season 1912–13 was as follows: Apples 4,693,000 bushels, valued at $5,289,000; nectarines and peaches 924,000 bushels, valued at $1,296,000; apricots 429,000 bushels; valued at $748,000; pears 1,100,000 bushels, valued at $803,000; bananas

1,139,000 bunches, valued at $693,000; pineapples 684,000 dozen, valued at $333,000; oranges 1,402,000 bushels, valued at $1,953,000; and lemons 375,000 bushels, valued at $430,000.

### EXPORTS.

During the five years 1909–1913 the value of the fruit exported from Australia averaged $2,157,000 annually. Fresh fruits contributed 83.4 per cent of this value, preserved fruits 11.1 per cent, and dried fruits 5.5 per cent. In addition, there were exported 1,078,000 gallons of domestic wines annually, valued at $586,000.

Apples comprised 68.8 per cent of the total value of the fruits exported during the five years named. Exports of apples averaged 47,317,000 pounds annually, valued at $1,483,000. Of the other fruits exported, the more important and their average annual value were citrus fruits $129,000, preserved fruits $123,000, raisins $66.000, dried currants $19,000, and pineapples $16,000. Apples, raisins, and wines were shipped principally to the United Kingdom, preserved fruits to the South African Union, and the other fruits to New Zealand.

### IMPORTS.

The value of the fruits imported into Australia during the five years 1909–1913 averaged $1,758,000 annually. Fresh fruits contributed 55.8 per cent of this value, dried fruits 26.2 per cent, and prepared or preserved fruits 18 per cent. In addition, there was imported annually wine, chiefly of French origin, to the value of $749,000. The principal fruits imported and their average annual value were bananas $683,000, dates $201,000, apples $152,000, citrus fruits $141,000, jams and jellies $49,000, and raisins $36,000. The bananas were obtained chiefly from the Fiji Islands, dates from Arabia, apples from the United States and Canada, and citrus fruits from Italy.

## NEW ZEALAND.

The area planted in commercial orchards in 1915 was 45,000 acres, as compared with 29,000 acres in 1908. Most of the fruit produced is consumed at home. During each of the past two seasons, however, between 60,000 and 70,000 cases of apples have been shipped to South America.

## HAWAII.

The most important fruit cultivated is the pineapple, especially since 1900, when the pineapple canning industry was begun in Hawaii. From 1,200 cases in 1900 the output of canned pineapples increased to 2,500,000 cases in 1915. The value of the pineapples exported during the fiscal year ending June 30, 1915, was $6,319,000, as compared with $5,062,000 in 1914. Most of this product is shipped to the United States. The banana is also an important item of export. During the five years 1911–1915 shipments of bananas from Hawaii to the United States averaged 208,000 bunches a year, valued at $129,000. Shipments of fruits to Hawaii from the United States during the same period averaged $259,000 a year, the chief items being oranges, apples, and canned fruits.

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BULLETIN No. 484

Contribution from the Bureau of Entomology, L. O. HOWARD, Chief
In cooperation with the Forest Service, HENRY S. GRAVES, Forester

Washington, D. C. PROFESSIONAL PAPER. April 9, 1917

# CONTROL OF THE GIPSY MOTH BY FOREST MANAGEMENT

## PART I: THE GIPSY MOTH IN WOODS

By G. E. CLEMENT, Assistant in Forest Management

## PART II: MANAGEMENT OF TYPICAL WOODLOTS INFESTED WITH THE GIPSY MOTH IN THE WHITE-PINE REGION

By WILLIS MUNRO, Assistant in Forest Management

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## INTRODUCTION.

The gipsy moth (*Porthetria dispar* L.) was first liberated in this country in 1868 or 1869, and 20 years later, about 1888, it became a very serious pest in the neighborhood in which it was liberated. Since then it has continued to spread, destroying both coniferous and deciduous foliage, until it is now found throughout a large part of eastern New England. (See map, p. 16.) It is particularly obnoxious because it feeds heavily on the foliage of so great a variety of trees and other forms of vegetation. Although many years have been spent in efforts to control the insect, it is still very abundant and in need of constant repression.

Trees may be classified as shade trees, fruit trees, and forest trees. Shade and fruit trees are more valuable, more accessible, and fewer in numbers than forest trees, and for these reasons have received much more attention than forest trees with respect to protection against gipsy-moth attack. Satisfactory means of protecting the first two classes of trees have been developed, but they are too expensive to be practicable in the case of forest trees. The problem of combating the gipsy moth in forests is a large one, and its solution will occupy many years.

Twenty years ago gipsy-moth caterpillars were reputed to be almost omnivorous. Studies made in more recent times by the

Bureau of Entomology have developed a number of important facts not formerly recognized. Among these are the following: (1) The foliage of some species of trees is more acceptable as food to gipsy-moth caterpillars than that of other species. (2) Caterpillars in the first stage of their development do not eat the foliage of conifers, except tamarack. These two facts apparently open up a considerable field for the use of forest management in the control of the insect.

Toward the end of the year 1912 Mr. W. F. Fiske, of the Bureau of Entomology, called attention to the gipsy moth as a forest insect and suggested the possibility of control by forest management.[1] In January, 1913, a cooperative agreement was entered into between the Bureau of Entomology and the Forest Service, providing for a full investigation of this matter. This investigation is now under way. It is based on the belief that infestation of woods can be reduced and possibly controlled by eliminating the species of trees which are particularly favored as food by gipsy-moth caterpillars and replacing such species with others which are less favored.

The object of the investigation is twofold. It is desired to ascertain in the first place in what proportions trees of different species can be associated to form stands which will not be subject to gipsy-moth ravages, and in the second place, the best method of converting existing stands into others better able to resist attack.

The plan for the work of this investigation provides for the establishment of sample plots in different kinds of typical forest stands in the infested region. Stands varying in composition, quality, age, climatic situation, and degree of gipsy-moth infestation are to be subjected to different forms of management with a view to determine what forms produce the safest stands and the best methods of establishing the most favorable conditions. During the past three years 46 sample plots have been established, and much of the prescribed work has been done on them. Several years must elapse before conclusions can be drawn from these experiments.

In the course of carrying out the work just referred to a number of facts have been observed, and it is believed that a presentation of these facts may be of interest.

## BEHAVIOR OF THE GIPSY MOTH IN THE WOODS.

The gipsy moth may be introduced into forests by the wind,[2] by caterpillars crawling from adjacent infested areas, or by transportation by man or animals.[3] The caterpillars begin feeding as soon as the new foliage appears in the spring and stop before the middle of July. A gipsy-moth colony may exist for several years in a wood without doing sufficient damage to attract any attention. The members of such a colony multiply in numbers continuously and spread over more and more territory until ultimately a point is reached where the caterpillars suddenly become so abundant that they defoliate large numbers of trees, frequently over wide areas.

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[1] Fiske, W. F. The Gipsy Moth as a Forest Insect, U. S. Dept. Agr. Bur. Ent. Circ. 164. 20 p. 1913.

[2] Collins, C. W. Dispersion of Gipsy Moth Larvæ by the Wind, U. S. Dept. Agr. Bul. 273. 23 p., 6 pl., 1 map. 1915.

[3] Burgess, A. F. The Dispersion of the Gipsy Moth, U. S. Dept. Agr. Bur. Ent., Bul. 119. 62 p., 6 fig., 16 pl., map. 1913.

Following a gipsy-moth defoliation over a considerable area, the intensity of an infestation generally diminishes. This is due largely to the following causes: (1) Caterpillars die of starvation or migrate on account of the exhaustion of their food supply. (2) An epidemic of the wilt disease destroys large numbers of the insects. (3) Natural enemies, particularly parasites and predacious beetles, reduce the infestation.

Woods which have suffered a heavy gipsy-moth attack are thus usually provided with some opportunity to recover. A few caterpillars survive in such cases, and in the course of a few years (three to five) defoliation again occurs. There is usually very heavy feeding following a season of defoliation if it happens, as it may occasionally, that an infestation is of such an extent that the amount of foliage available is just sufficient to carry the caterpillars to the pupation stage.

An infestation once established in a wood will probably remain as long as the food supply lasts, but the degree of infestation will vary from time to time.

The development and extent of gipsy-moth infestations are influenced to a large degree by meteorological conditions, insect enemies, and the wilt disease. Owing to the uncertainty with which these factors act, it is impossible to make a definite prediction as to the exact outcome of any infestation.

Feeding occurs in varying degrees over all the infested region, the extent in any locality depending on the stage of the infestation and the character of the food. After defoliation most trees immediately put forth new foliage, and in a few weeks there is usually but little external evidence of damage. In such cases the injury amounts only to a temporary retardation of development, and from this the trees attacked usually recover. Trees previously weakened through the action of decay, fire, or poor growing conditions may not survive one defoliation, but mortality through this cause is low.

Gipsy-moth feeding does not cease until after most of the early summer rains have fallen, so that defoliated trees in their weakened condition encounter more or less unfavorable conditions for their recovery. An unusually dry summer may influence recovery very adversely. Defoliation by gipsy-moth caterpillars usually occurs when the larvæ are in the very last stages, but occasionally defoliation is effected by caterpillars in earlier stages, in which case the defoliated trees have a better chance to recover, because there remains a longer period than usual in which they may grow and recuperate.

Repeated defoliation from year to year will ultimately kill any tree or render it susceptible to the attacks of bark borers, which produce the same result. In the gipsy-moth region repeated annual defoliation may result from the combined activities of the gipsy moth, brown-tail moth (*Euproctis chrysorrhoea* L.), forest tent caterpillar (*Malacosoma disstria* Hübn.), and several other common species. Thus, at times when gipsy moths are not abundant, trees previously stripped of foliage by them would doubtless often recover were it not for the activities of other defoliators. Brown-tail moth larvæ cease feeding not later than the middle of June, so that defoliated trees have the advantage of a part of the spring precipitation, and more time to recuperate before the end of the growing season.

Oaks have suffered the highest mortality among defoliated forest trees, probably because of the action of the two-lined chestnut borer (*Agrilus bilineatus* Weber), whose work is usually present beneath the bark of all dead specimens. Many defoliated oaks which have died would doubtless have recovered had it not been for the additional injury produced by this borer. Oaks, more than any other species, are found growing in unfavorable situations in the infested region, which, together with the fact that the infested region includes the northern limit of the range of the white oak, is responsible for many oaks of poor physical condition. Trees in poor condition are particularly liable to serious damage by defoliation, especially in connection with attack by the two-lined chestnut borer, which infests only weakened trees. The removal of dying oaks would not only help to reduce a gipsy-moth infestation, but would reduce the numbers of Agrilus and create room for species of trees for which the situation is more favorable.

## COMPOSITION AND CONDITION OF WOODS IN INFESTED TERRITORY.

At present the gipsy-moth infestation is largely confined to what Hawley and Hawes[1] have designated the White-pine Region. The northern part of the infested region in Maine and New Hampshire extends a little into the "Northern Hardwoods Region," and the infested portions of Rhode Island and Connecticut lie in the "Sprout Hardwoods Region."

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[1] Hawley, R. C., and Hawes, A. F., Forestry in New England; a Handbook of Eastern Forest Management. New York, 1912. 479 p. (P. 196.)

The White-Pine Region is broadly characterized by stands of (1) pure white pine, (2) mixed white pine and hardwoods, and (3) mixed hardwoods. The predominating hardwoods in this region are the oaks. Other hardwoods are birches, beech, maples, hickories, ashes, poplars, and chestnut. Pitch pine occurs in pure stands over certain small portions.

The Northern Hardwoods Region is characterized by stands of maples, beech, and birches. The sugar maple, beech, and yellow birch are particularly characteristic. Spruce, white pine, and hemlock also occur in the region, together with red oak, white ash, black ash, black cherry, paper birch, and basswood.

The Sprout Hardwoods Region is characterized by stands of chestnut, either pure or in mixture with several species of oak. Other hardwoods occurring in this region are maples, ashes, birches, poplars, tulip, and hickories.

The stands in all three of the regions vary greatly in composition and are frequently very complex. This is largely due to the usual methods of lumbering and to the repeated action of fire. Stands have been repeatedly culled or cut clear with no provision for reproduction. This system and repeated fires have been responsible in many cases for the extensive introduction of species which would otherwise be absent or be represented by only a few individuals.

A large amount of neglected pasture and cultivated land in New England is reverting to woods. The trees which generally spring up on such lands are white pine, gray birch, red cedar, poplar, pin cherry, and, in places, red maple. The stands thus derived are usually very open for a long period of time, and the quality, aside from the composition, is therefore poor.

Large blocks of woodland under single ownership are rather scarce, and the woods for the most part occur on more or less isolated small lots belonging to many different owners. Owing to this fact and to the great diversity in the composition of woods, even on small areas, it is impossible to classify the stands of timber growing in the infested region except in a very general way.

The complexity and variable composition of the woods in the region infested by the gipsy moth are indicated by the table (p. 6). This shows the composition of the stands on some of the areas used for experimental work, and the trees are only the living ones which are two and a half inches in diameter and over at breast height.

*Complexity and variable composition of woods in the area infested by the gipsy moth.*

1 acre in Dover, Mass. Mixed hardwoods.

| Species: | *Per cent.* |
|---|---|
| Red oak | 45 |
| White oak | 38 |
| Black oak | 11 |
| White pine | 3 |
| Red maple | (1) |
| Gray birch | (1) |
| Pignut hickory | (1) |
| White ash | (1) |
| | 100 |

2½ acres in Exeter, N. H. Mixed hardwoods.

| Species: | *Per cent* |
|---|---|
| Red oak | 31 |
| White oak | 30 |
| Black oak | 28 |
| Red maple | 7 |
| White pine | 4 |
| Gray birch | (1) |
| Pignut hickory | (1) |
| Black birch | (1) |
| Beech | (1) |
| Pitch pine | (1) |
| Yellow birch | (1) |
| Aspen | (1) |
| Black cherry | (1) |
| Elm (American) | (1) |
| Apple | (1) |
| | 100 |

5.4 acres in Wareham, Mass. Mixed hardwoods.

| Species: | *Per cent.* |
|---|---|
| Scarlet oak | 54 |
| White oak | 21 |
| White pine | 15 |
| Black oak | 8 |
| Pitch pine | 1 |
| Red oak | (1) |
| Red maple | (1) |
| Gray birch | (1) |
| Black gum | (1) |
| | 100 |

1.3 acres in Medfield, Mass. Mixed hardwoods.

| Species: | *Per cent.* |
|---|---|
| Chestnut | 52 |
| Red oak | 21 |
| White oak | 10 |
| White pine | 9 |
| Black oak | 7 |
| Red maple | 1 |
| | 100 |

4.2 acres in Amesbury, Mass. White pine and mixed hardwoods (old-field growth).

| Species: | *Per cent.* |
|---|---|
| White pine | 28 |
| Gray birch | 21 |
| Black oak | 16 |
| Red maple | 10 |
| Pitch pine | 8 |
| White oak | 5 |
| Red cedar | 5 |
| White ash | 2 |
| Swamp white oak | 1 |
| Chestnut | (1) |
| Red oak | (1) |
| Black birch | (1) |
| Pignut hickory | (1) |
| Butternut | (1) |
| Aspen | (1) |
| Wild red cherry | (1) |
| American elm | (1) |
| Hop hornbeam | (1) |
| Apple | (1) |
| | 100 |

3.4 acres in North Berwick, Me. Northern hardwoods.

| Species: | *Per cent.* |
|---|---|
| Beech | 45 |
| Hop hornbeam | 16 |
| Sugar maple | 14 |
| Red maple | 8 |
| Black birch | 4 |
| Hemlock | 4 |
| Yellow birch | 3 |
| Red oak | 2 |
| Paper birch | 2 |
| White ash | 1 |
| Big-tooth poplar | (1) |
| Basswood | 1 |
| American elm | (1) |
| Black ash | (1) |
| | 100 |

11 acres in Westbrook, Me. White pine and mixed hardwoods.

| Species: | *Per cent.* |
|---|---|
| White pine | 28 |
| Red oak | 21 |
| Gray birch | 20 |
| Red maple | 16 |
| Hemlock | 7 |
| Paper birch | 3 |
| Shagbark hickory | 2 |
| Balsam fir | 1 |
| White ash | 1 |
| Big-tooth poplar | 1 |
| Choke cherry | 1 |
| Hop hornbeam | 1 |
| Pitch pine | (1) |
| Chestnut | (1) |
| Black oak | (1) |
| Sugar maple | (1) |
| Beech | (1) |
| | 100 |

[1] Less than 1 per cent.

The physical condition of the trees composing the woods in the infested region is extremely poor, due largely to the action of repeated fires which destroy the litter and decomposed vegetable matter so essential to successful tree growth. Fire is also responsible for physical injury to trees and the admission through fire wounds of injurious fungi and insect borers. A very high percentage of the deciduous trees in the infested region is of sprout origin. The stools from which these have sprung are often worn out and more or less decayed, and from such impaired stock it is unreasonable to expect successful tree growth.

Owing to poor physical condition, small size, and limited proportion of desirable species, the woods of the infested region are of relatively low commercial value. Under present conditions a large quantity of the white pine is suitable only for box boards, and a large portion, possibly 75 per cent, of the deciduous growth is suitable only for fuel.

The composition and physical condition of woods subject to gipsy-moth infestation have a very important bearing on the extent of the damage which may ensue therefrom. Coniferous trees grown in pure stands are immune from any considerable damage. The ashes are seldom attacked, and the red maple, sugar maple, hickories, and chestnut are not seriously affected. The proportions of such species occurring in stands have considerable influence upon the degree of damage done. Trees weakened by drought, fungi, fire, suppression, or other unfavorable growing conditions can offer only a weak resistance to the effects of defoliation and so are much more likely to succumb than vigorous trees.

The presence of dying and weakened trees in a wood is very objectionable, inasmuch as such trees harbor injurious borers, and these multiply rapidly when favorable conditions for their entrance into other trees are provided by defoliation.

The forests of the infested region are highly valued for their attractiveness and the protection they afford. There is probably no region in which the esthetic features of woods are more valued than in New England, and there are numerous instances where they are maintained largely out of consideration for their appearance. Woods thus maintained are generally of better quality than others, but there is usually a chance to increase the commercial value of many such stands. Such improvement would not impair esthetic values.

It is quite impossible to appraise the damage inflicted upon owners of woods by gipsy moths. The woods vary so much in composition and quality, and individual trees suffer in such varying degree, that there is no available basis for such an estimate. The esthetic value which an owner or community places upon woods adds to the difficulty of such an appraisal. Individuals and communities have frequently gone to large expense to protect inferior stands of timber against the ravages of the gipsy moth, and in such cases the reduction of infestations is of greater importance than the conservation of the woods alone, since adjoining fruit and shade trees are thereby protected.

The scarcity and corresponding values of forest products of good quality in New England appear to justify an outlay in improvement measures. Trees capable of producing only material of low value should be removed and replaced by more valuable species. Defective and dying individuals should be made to give way to vigorous trees. Trees growing on sites on which other species will yield greater values should be replaced by such species. The complexity of many stands should be greatly reduced, for it is a very difficult matter to grow together successfully a large variety of trees varying widely in their requirements.

The expense necessary to bring about the desirable changes would be the following: (1) The sale of a lower grade, and hence a less profitable product than would be available under present methods. (2) Added expense of cutting, owing to the greater cost of cutting scattered trees instead of cutting clear. (3) Added expense of cutting, owing to the effort which should be made to protect young growth of desirable species already started on the ground. (4) The cost of planting desirable species where these can not be procured by natural seeding.

## FEEDING HABITS OF GIPSY-MOTH CATERPILLARS.

The Bureau of Entomology has conducted extensive experiments to ascertain the feeding habits of the gipsy moth. The methods used and the results obtained have been described by Mosher.[1] The results of these experiments have considerable bearing on any forest management which may be prescribed in an effort to control infestations in woods.

Mosher has classified the trees and shrubs of the region according to susceptibility to gipsy-moth attack. This classification includes several species of trees which are not indigenous and some which occur almost exclusively as ornamental trees. Following is a list of only the indigenous and naturalized forest trees of the region as classified by Mosher. The nomenclature used here is that which has been adopted as standard by the Forest Service. It varies slightly from that used in Bulletin No. 250.

**Class I: Species that are favored food of the gipsy-moth larvæ in all their stages.**

Ash, Mountain (*Sorbus americana* Marsh.).
Aspen (*Populus tremuloides* Michx.).
Aspen, Large-tooth (*Populus grandidentata* Michx.).
Balm of Gilead (*Populus balsamifera* Linn.).
Basswood (*Tilia americana* Linn.).
Beech (*Fagus atropunicea* [Marsh.] Sudw.).
Birch, Gray (*Betula populifolia* Marsh.).
Birch, Paper (*Betula papyrifera* Marsh.).
Birch, River (*Betula nigra* Linn.).
Boxelder (*Acer negundo* Linn.).
Oak, Black (*Quercus velutina* Lam.).
Oak, Bur (*Quercus macrocarpa* Michx.).
Oak, Chestnut (*Quercus prinus* Linn.).
Oak, Pin (*Quercus palustris* Muench.).
Oak, Post (*Quercus minor* [Marsh.] Sargent).

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[1] Mosher, F. H. Food Plants of the Gipsy Moth in America, U. S. Dept. Agr. Bul. 250. 39 p., 6 pl. 1915.

Oak, Red (*Quercus rubra* Linn.).
Oak, Scarlet (*Quercus coccinea* Muench.).
Oak, Scrub (*Quercus pumila* [Marsh.] Sudw.).
Oak, Swamp white (*Quercus platanoides* [Lam.] Sudw.).
Oak, White (*Quercus alba* Linn.).
Service Berry (*Amelanchier canadensis* [Linn.] Medic.).
Sumac, Dwarf (*Rhus copallina* Linn.).
Sumac, Staghorn (*Rhus hirta* [Linn.] Sudw.).
Tamarack (*Larix laricina* [Du Roi] Koch.).
Willow, Glaucous (*Salix discolor* Muehl.).
Witch Hazel (*Hamamelis virginiana* Linn.).

**Class II: Species that are favored food for gipsy-moth larvæ after the earlier larval stages.**

Chestnut (*Castanea dentata* [Marsh.] Borkh.).
Hemlock (*Tsuga canadensis* [Linn.] Carr.).
Pine, Pitch (*Pinus rigida* Mill.).
Pine, Red (*Pinus resinosa* Ait.).
Pine, White (*Pinus strobus* Linn.).
Spruce, Black (*Picea mariana* [Mill.] B. S. P.).
Spruce, Red (*Picea rubens* Sargent.).
Spruce, White (*Picea canadensis* [Mill.] B. S. P.).

**Class III: Species that are not particularly favored, but upon which a small proportion of the gipsy-moth larvæ may develop.**

Beech, Blue (*Carpinus caroliniana* Walt.).
Birch, Black (*Betula lenta* Linn.).
Birch, Yellow (*Betula lutea* Michx.f.).
Cherry, Black (*Prunus serotina* Ehrh.).
Cherry, Choke (*Prunus virginiana* Linn.).
Cherry, Wild Red (*Prunus pennsylvanica* Linn.f.).
Cottonwood (*Populus deltoides* Marsh.).
Elm, American (*Ulmus americana* Linn.).
Elm, Slippery (*Ulmus pubescens* Walt.).
Gum, Black (*Nyssa sylvatica* Marsh.).
Hickory, Bitternut (*Hicoria minima* [Marsh.] Britton).
Hickory, Mocker-nut (*Hicoria alba* [Linn.] Britton).
Hickory, Pignut (*Hicoria glabra* [Mill.] Britton.).
Hickory, Shagbark (*Hicoria ovata* [Mill.] Britton).
Hop Hornbeam (*Ostrya virginiana* [Mill.] Koch.).
Maple, Red (*Acer rubrum* Linn.).
Maple, Silver (*Acer saccharinum* Linn.).
Maple, Sugar (*Acer saccharum* Marsh.).
Poplar, Silver (*Populus alba* Linn.).
Sassafras (*Sassafras sassafras* [Linn.] Karst.).

**Class IV: Species that are unfavored food for gipsy-moth larvæ.**

Arborvitæ (*Thuja occidentalis* Linn.).
Ash, Black (*Fraxinus nigra* Marsh.).
Ash, Red (*Fraxinus pennsylvanica* Marsh.).
Ash, White (*Fraxinus americana* Linn.).
Balsam Fir (*Abies balsamea* [Linn.] Mill.).
Butternut (*Juglans cinerea* Linn.).
Cedar, Red (*Juniperus virginiana* Linn.).
Cedar, White (*Chamaecyparis thyoides* [Linn.] B. S. P.).
Dogwood, Flowering (*Cornus florida* Linn.).

Hackberry (*Celtis occidentalis* Linn.).
Holly, American (*Ilex opaca* Ait.).
Laurel, Mountain (*Kalmia latifolia* Linn.).
Locust, Black (*Robinia pseudacacia* Linn.)
Locust, Honey (*Gleditsia triacanthos* Linn.).
Maple, Mountain (*Acer spicatum* Lam.).
Maple, Striped (*Acer pennsylvanicum* Linn.).
Mulberry, Red (*Morus rubra* Linn.).
Sheepberry (*Viburnum lentago* Linn.).
Sycamore (*Platanus occidentalis* Linn.)
Tulip (*Liriodendron tulipifera* Linn.).
Walnut, Black (*Juglans nigra* Linn.).

Shrubs occur frequently as undergrowth in the woods of the infested region and may have an important bearing on the infestation of the trees growing above or around them. A stand of such species of trees as are not fed upon until the larvæ reach their later stages might be immune from damage were it not that the larvæ are enabled to reach these later stages by feeding on near-by shrubs. Most of the shrubs which grow in the region die out if sufficiently shaded, and the balance occur so rarely in shade or are eaten to such a slight degree by gipsy-moth larvæ that they are unimportant. If forests were under management the danger of woods thus being infested would be eliminated, because in a properly managed forest the trees should be so grown that they produce at all times an amount of shade sufficient to preclude the development of shrubs in any numbers.

Larvæ feeding on shrubs which are favored food plants, occurring in open land adjacent to woods, might migrate to the woods, but would not penetrate very far if the trees of the stands were of any but those of Class I.

The following statement appears on page 27 of Bulletin 250: "There is in some cases, at least, considerable variation in susceptibility of different trees of the same species." This should be considered carefully in connection with any form of management which prescribes the removal of certain trees on the ground that they are liable to infestation.

## PRECAUTIONS NEEDED.

Natural enemies of the gipsy moth, in particular those introduced from abroad, are constantly increasing in numbers, and their influence is a large factor in the control of the moths in woods. It is safe to assume that this increase in numbers is going to continue and that in the future the character of gipsy-moth damage to woods will thereby be greatly modified.

In view of the above, and of the fact that it is impossible definitely to predict the outcome of an infestation under any circumstances, it is unwise to attempt to eliminate any particular species out of consideration for susceptibility to gipsy-moth attack alone. There is sufficient cause for removing many trees on the ground that they are mature, dying, defective, unfavorably situated, or interfering with the development of better trees. It is not good forest policy to remove any thrifty young tree until it has been given every opportunity to yield a return on the investment which it represents. To remove such young trees would be similar to abandoning a crop of young potato plants because of the appearance of the potato beetle.

Sawmill men have frequently induced owners to sell standing white pine by asserting that the trees were doomed to destruction by the presence of the gipsy moth. An owner believing this is likely to be induced to sell his stumpage at whatever price the sawmill man may choose to offer him. This practice has resulted in the cutting of immature trees which would have yielded a greater profit to the owner if permitted to mature. *No owner who is unfamiliar with the action of the gipsy moth in woods should permit himself to be influenced by a timber buyer to part with thrifty trees of any sort on the ground that the trees are liable to attack by gipsy moths. The advice of State and Federal officers who are familiar with the problem is available to any owner of woods in the region.*

The poor condition of woods, combined with the damaging effect of gipsy-moth attack, makes improvement and protective measures imperative. Introduced enemies of the gipsy moth are becoming well established and are doing effective work, and the wilt disease prevails throughout the region.[1] Still the woods continue to be defoliated by gipsy moths, and further protective measures are in demand.

Any plan for the silvicultural improvement of stands of trees should provide for the removal of dead, dying, mature, and defective trees, trees standing in unfavorable situations, and trees of low commercial value. It should provide for the replacement of these removed trees with thrifty trees of high commercial value well adapted to their environment. It should also provide for a compact stand of trees without overcrowding. Such action alone would constitute a protective measure of great value, but if it could be extended to embrace the removal of trees and conditions favorable to the development of the gipsy moth and the replacement of these by trees and conditions unfavorable to the gipsy moth, a still greater degree of protection would be provided.

## APPLICATION OF FOOD-PLANT DATA TO INDIVIDUAL SPECIES.

The classification of trees on the basis of the extent to which they are fed upon by gipsy moths (p. 8–10) is one which may well be used in the production of stands of trees which shall be free from gipsy-moth damage. A detailed consideration of the classification in this light is interesting and may prove of value in combining protective with improvement measures.

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[1] Glaser, R. W. Wilt of gipsy moth caterpillars. *In* U. S. Dept. Agr. Jour. Agr. Res., v. 4. No. 2, p. 101–128, 17 fig., May 15, 1915. (P. 102.)

Class I (p. 8) is composed of 26 species which are favored food of gipsy-moth larvæ. Ten of these species, mountain ash, gray birch, river birch, boxelder, scrub oak, service berry, dwarf sumac, staghorn sumac, glaucous willow, and witch hazel, yield products of low commercial value and should in any case be eliminated from mixed woods.

Ten of the species in this class are oaks, including the scrub oak just referred to. All oaks require the best of forest soils to develop well and profitably. Oaks growing on thin soils, rocky ridges, and very sandy soil are usually not very vigorous and frequently suffer severely from gipsy-moth attack. If oaks were removed from the unfavorable sites on which they very often occur and were confined to sites best adapted to their requirements, a large amount of gipsy-moth food would be eliminated, a better quality of oak would be produced, and there would be available a considerable acreage of forest land better suited to the growth of other valuable trees.

The bur oak, chestnut oak, pin oak, post oak, and swamp white oak are generally more or less rare and of restricted local occurrence in the infested region. On account of their scattered distribution they are not of any great commercial importance here. In consideration of their susceptibility to moth attack and capacity for maintaining infestations, they could well be spared from most stands in which they occur.

The white oak reaches the northern limit of its range in the infested region, but still is one of the most abundant of the oaks. This abundance is abnormal and is due to the sprouting capacity of the species, resistance to the effect of fire, and current methods of cutting. The trees grow very slowly and seem to be particularly favored by both gipsy and brown-tail moths. A very large proportion of the existing trees of this species could be removed to great advantage.

The red oak, black oak, and scarlet oak do well in the infested region, and it is hoped that the experiments now under way will show that there may be conditions under which they may be safely grown.

The following poplars occur in Class I: Aspen, large-tooth aspen, and balm of Gilead. These species all demand a large amount of light and occur only where it can be procured. As a result they generally occur scattered in mixed woods, and pure where they can get the necessary start. They grow rapidly, and when they occur in any abundance are in good demand for excelsior and pulp manufacture. There is some question as to what extent they should be encouraged in view of their susceptibility to gipsy-moth attack.

Basswood occurs very much scattered in the infested region. It grows to advantage only on the best sites and should be eliminated from all others.

Beech occurs most abundantly in the northern portion of the region. It grows slowly and is liable to become defective before maturity. It is perhaps the least liable to damage of any Class I trees.

Paper birch demands a great deal of light and is not abundant in mixed stands. Where it occurs in abundance it is in great demand for spool and novelty wood. Scattered specimens may be replaced with species which are less liable to gipsy-moth attack.

Tamarack is nowhere abundant in the infested region. It is a tree which can well be cut out when found outside of pure stands. It is the only conifer which is eaten by the youngest gipsy-moth larvæ.

Class II (p. 9) is composed of eight species of trees on which gipsy-moth caterpillars in their earliest stages do not feed, but upon which they do feed in their later stages. Young caterpillars must have food, and if this is not available they can not attain the point in their development where they can feed on the trees of this class. Hence if stands of these trees have in their vicinity no plants upon which the young caterpillars can feed, the stands are practically immune from attack. Trees of this class can therefore be safely grown in pure stands, in mixture, where conditions permit, with one another, or in mixture with Class IV trees.

Stands composed largely of one or more of the species of this class can be made immune from gipsy-moth attack by removing the plants which may provide young larvæ with food. Since most of the species which are susceptible to gipsy-moth attack are deciduous, provision in this case will have to be made for the suppression of the sprouts which follow cutting.

Trees of this class may be substituted frequently for removed trees of species susceptible to moth attack. The white pine is particularly important in this respect, owing to its commercial value, rapidity of growth, and adaptability to a variety of sites. The red pine, while somewhat slower growing and of slightly less value, is also a valuable tree and deserves particular consideration owing to its immunity from the white-pine blister rust.

Chestnut is the only deciduous tree of this class. It grows well and yields a valuable product, but unfortunately is subject to attacks of the chestnut blight. In the light of existing conditions the propagation of this species can not be advocated.

Class III (p. 9) is composed of 20 species which are not particularly favored, but upon which a small proportion of gipsy-moth larvæ may develop. Stands composed of any trees of this class and containing none of the trees of Class I would maintain slight infestations and would rarely, if ever, be defoliated.

Blue beech, choke cherry, wild red cherry, hop hornbeam, and sassafras have no particular commercial value, and the elimination of these species from stands would afford some degree of protection.

Black cherry has considerable commercial value, but occurs very scatteringly. As it is not a favored food, it may well be left in view of its value. American elm and slippery elm also occur as scattered trees. Their value is less than black cherry, but they might well be left. Cottonwood, bitternut hickory, black gum, silver maple, and silver poplar if found might well be eliminated from most stands. Such an elimination would help to reduce the complexity of stands and would serve as a protective measure.

The remaining species of this class, black and yellow birch, mockernut, pignut and shagbark hickories, and red and sugar maple, can be grown in comparative safety. In any process of gradual transformation these species should be retained in preference to the trees of Class I.

Class IV (p. 9) is composed of trees on which the gipsy moth does not feed, or if it does, the amount is so slight as to be entirely negligible. Stands composed of trees of this class alone, or combined with the trees of Class II, need cause no anxiety whatever as far as gipsy-moth attack is concerned. Some of the species of this class are of rare occurrence, some require peculiar conditions for their development, and some have little or no commercial value. Arborvitæ, black ash, and white cedar require very moist situations and usually occur in or near swamps. Butternut, red cedar, locust, honey locust, and sycamore all require a large amount of light. The red ash, hackberry, American holly, red mulberry, tulip, and black walnut are of rare and local occurrence, for which reason they can not be depended upon to supply any large commercial demand. Flowering dogwood, mountain laurel, mountain maple, striped maple, and sheepberry have little or no commercial value locally. The white ash has a high commercial value, but should be confined to the best forest soils.

In general, it may be said that stands containing only trees of Classes II, III, and IV will suffer but slight damage from gipsy-moth attack. The number of Class I trees would be tremendously reduced if the worthless species were replaced by suitable trees and the remainder were confined to the best sites, as is necessary if they are to be grown at all profitably.

Any plan for the removal of trees must provide for their replacement with more desirable ones. All trees may be removed in one operation and replaced in another, or the transformation may be gradual. There are many conditions which influence the methods to be employed, and these vary greatly among different stands. It is hoped that the experiments now in operation will provide a basis for definite recommendation as to the best methods to be employed under some of the most characteristic conditions.

Forest management requires a relatively long time to produce results and necessitates a considerable investment. For these reasons a definite object and plan of action are essential to success. In a large majority of cases the primary object is to produce a valuable crop of timber. The object must be decided by the owner, but methods to be employed require the knowledge of a forester, since the values and habits of different species of trees and the character of soils must be known and should have expert consideration.

## OTHER MEASURES IN NEED OF ATTENTION.

There is a need of a wide application of any steps adopted to control the gipsy moth in woods. The efforts of scattered individual owners may be offset by the indifference of neighboring owners on whose properties the moths are permitted to increase without interruption. On account of the greatly divided ownership of woodland in the infested region, this amounts to a considerable obstacle. There is great need of impressing upon owners the necessity of concerted action in the improvement and protection of their woods. How this can be accomplished is a problem to which immediate attention should be given.

The woods of New England have reached their present stage of degeneracy through a long period of abuse and neglect, and it will take years to restore them. Owing to the nature of the ownership of our woods and present economic conditions restorative measures must be simple and practicable for all owners. More good will be accomplished by the universal adoption of simple but definite improvement measures than by the sporadic application of intensive measures. As soon as the value of such a beginning has been demonstrated owners will be ready enough to adopt further measures, and by that time these will be better justified by economic conditions. Improvements necessitate the investment of money, and the value of such improvements must be demonstrated before they will be generally adopted. One of the greatest needs among New England wood owners is that they may be impressed individually with the necessity and desirability of starting some definite, if simple, improvement measures at once.

The difficulty of securing concerted action upon protective measures against the gipsy moth has directed attention to the question of town forests, one which is now being agitated to some extent in New England. Town forests would provide areas of considerable size upon which systematic control measures could be put into operation with assurance of a fair trial. Such conditions would be most favorable to the solution of such a problem as the one under consideration. Furthermore, town forests would supply other benefits, among which the following may be mentioned: (1) Large areas of waste land could be made to yield an income. (2) Communities would be provided with a permanent local supply of wood products, the use of which for manufacturing purposes would insure a certain amount of local industrial activity. (3) Private owners would be supplied with examples of the value of systematic management. (4) Communities would have convenient recreation grounds of the most desirable sort. (5) An opportunity would be given to begin now to establish forests of quality to meet future needs. Most individual owners lack the means or the desire to adopt such a policy, although everyone realizes the need of such measures.

The low commercial value of most of the trees suggested for removal and the cost of restocking land with new trees combine to prohibit in many instances the adoption of obviously desirable improvement and protective measures. A vigorous effort should be made to stimulate the existing market for inferior hardwoods and to discover new uses for such woods. If an active demand for low-grade hardwoods could be created, the problem of controlling the gipsy moth in woods would be much easier than under present conditions.

## RECOMMENDATIONS.

The following recommendations are made in the belief that their adoption would be of great value in the solution of the problem of the control of the gipsy moth in woods. It is therefore recommended:

(1) That steps be taken to impress on every individual woodland owner the desirability of adopting and practicing simple but definite improvement and protective measures. (2) That the following suggestions be carefully considered by woodland owners who wish to improve and protect their woods:

(*a*) Cut all trees designated as of low commercial value in Class I when they are shading or in any way interfering with the growth and development of trees in Classes II, III, and IV.

(*b*) Cut all species indicated as being of low commercial value in Classes III and IV when they are in any way interfering with the growth of valuable species in the same classes.

(*c*) Cut as soon as possible all trees which have started to die. Dying trees often breed very injurious borers.

(*d*) Cut no thrifty trees merely out of fear that they will be attacked by insects, excepting in cases where extreme suppressive measures make it necessary. Many insect-ridden trees have recovered fully.

(*e*) Cut no thrifty tree that is not interfering with the growth of a more valuable one unless it can be replaced by something better.

(*f*) Confine hardwood growth as far as possible to the best available soils.

(*g*) Encourage the growth and development of conifers, particularly white pine, on all sites not well adapted to hardwood growth.

(*h*) Keep woodland so completely stocked with trees that undergrowth providing gipsy-moth food will be shaded out.

(3) That the establishment of public forests be given every encouragement.

# PART II: MANAGEMENT OF TYPICAL WOODLOTS INFESTED WITH THE GIPSY MOTH IN THE WHITE-PINE REGION.

By WILLIS MUNRO,

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The preceding pages have been devoted to the general subject of the gipsy moth in woods. In those which follow an attempt will be made to coordinate the results of the food-plant experiments with known principles of forest management and with economic conditions in the infested region, to see how far we may reasonably expect to rely upon forest management to control the moth.

## SUSCEPTIBILITY TO GIPSY-MOTH ATTACK AS A BASIS OF MANAGEMENT.

### TYPICAL STANDS COMPARED.

The composition of some of the statnds used in the management experiments was shown in Part I (p. 6). By taking these same stands and grouping the species according to their susceptibility to attack by the gipsy moth, as determined by Mosher[1] we get the following results:

*Composition of stands by percentage of susceptible trees present.*

| Classes of trees based on acceptability as food for gipsy-moth caterpillars. | Dover, Mass. | Exeter, N. H. | Wareham, Mass. | North Berwick, Me. | Amesbury, Mass. | Medfield, Mass. |
|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| I. Favored food in all larval stages | 94 | 88 | 83 | 50 | 45 | 38 |
| II. Favored food after earlier stages | 3 | 4 | 16 | 4 | 36 | 61 |
| III. Not particularly favored food | 2 | 8 | 1 | 45 | 12 | 1 |
| IV. Unfavored food | 1 | ........ | ........ | 1 | 7 | ........ |
| Whole stand | 100 | 100 | 100 | 100 | 100 | 100 |
| Number per acre alive | 510 | 291 | 306 | 407 | 321 | 426 |
| Average diameter breast high in inches | 4.9 | 6.1 | 7.0 | 6.5 | 4.9 | 6.6 |
| Number of species | 8 | 15 | 9 | 14 | 19 | 6 |

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[1] Food Plants of the Gipsy Moth in America, F. H. Mosher, Bulletin 250, U .S. Dept. of Agriculture, 1915.

These stands were carefully selected after a thorough search of the infested region to find stands having varying proportions of different species, and they are typical of the region.

It will be noticed that in the first four the Class I trees (favored food of the gipsy-moth caterpillar) from 50 to 94 per cent of the whole stand. It is obvious that in such cases any plan which prescribes the removal of all Class I trees involves a radical change in composition and can not be efficacious unless the sprouts which follow cutting are also removed.

This classification of trees according to their susceptibility to attack by the gipsy-moth caterpillar, though based upon careful experiments in the laboratory and extended observations in the field, is not absolute. In some cases it may have a direct bearing upon forest management in the region infested with the gipsy moth, but it is not yet conclusive as to moth control, for there is a wide range, for example, between the susceptibility of white oak and of beech, which are both Class I trees. It is, therefore, subject to revision, if later experiments or field observations should require it.

## OTHER FACTORS IN MANAGEMENT FOR MOTH CONTROL.

A sound plan for moth control by forest management must be based not only upon the susceptibility of the trees to attack by the caterpillars and upon their silvicultural requirements as individuals and as component parts of the stands in which they occur, but also upon the degree of infestation. In the work of the Bureau the degree of infestation by the gipsy moth is determined by counting the number of egg clusters, each containing from 300 to 500 eggs and laid by a single female.

The number of egg clusters per acre at any given date, while by no means satisfactory, is the best standard as yet available by which to compare the degree of infestation in different stands, or in the same stand in different years. It is, of course, a better index of the defoliation to be expected the next year than of that which occurred the year the eggs were laid, and as such becomes a factor in management for moth control. It should be remembered, however, that when very high figures are reached relief may reasonably be expected from outbreaks of the wilt disease,[1] migration of the caterpillars, attacks by parasites and other insect enemies, starvation, or other natural causes.

## SOME CONTROLLING FACTORS IN MANAGEMENT.

Since Mosher has concluded that "tray work and field observations show that the white oak is probably the most favored food plant of the gipsy moth," the percentage of white oaks has been selected as a basis of comparison for the six stands now under consideration.

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[1] Glaser, R. W., and Chapman, J. W. The wilt disease of gipsy moth caterpillars. *In* Jour. Econ. Ent., v. 5, p. 479–488, 1913. See Bibliography, p. 487–488.

The percentage of white oaks present gives a natural and definite basis of comparison which has a direct bearing upon both management and moth control.

With the exception of tamarack, there are no conifers among Class I trees (favored food of the caterpillar). As there is no tamarack on any of the lots now under consideration, the retention of conifers is an important factor in moth control in these stands. In any stand the leading species—that occurring in the greatest number—requires careful consideration both as a food plant and as a forest tree if success is to be expected. The presence in large numbers of young growth of species desirable from both viewpoints is also important. This brief statement by no means includes all factors which must be considered, but the suggestions given below are based upon them and upon markets as controlling factors in management. For convenience of reference four of the important factors are summarized in the form of a table which follows:

*Some controlling factors in management.*

| Stand at— | White oak. | Conifers. | Leading species. | | Number of gipsy-moth egg clusters per acre in 1913. |
|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | | *Per cent.* | |
| Dover, Mass. | 38 | 3 | Red oak | 45 | 15,000 |
| Exeter, N. H | 30 | 4 | do | 31 | 949 |
| Wareham, Mass. | 21 | 16 | Scarlet oak | 54 | 12 |
| Medfield, Mass. | 10 | 9 | Chestnut | 52 | 4,374 |
| Amesbury, Mass. | 5 | 41 | White pine | 28 | 550 |
| North Berwick, Me. | .......... | 4 | Beech | 45 | 1 |

## TREES WHICH CONTROL.

From the list of 150 food plants of the gipsy moth, published in Bulletin 250, there were selected and considered in Part I all native or naturalized trees which might be found in woods in the infested region. Seventy-five species are included, and the list is given on pages 8–10.

When sufficiently numerous in a stand these would be leading species, as that term has been defined above, and by that fact alone they might become controlling factors in management, but many trees[1] in the list occur so infrequently or are so small that their presence or absence in a stand would have no controlling effect upon the form of management to be practiced.

Of the whole 75 species only 18 have silvical characteristics which, apart from any considerations of commercial value or of moth control, make it impossible to disregard them if success is to be expected in managing a stand in which they are present.

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[1] See Appendix, p. 51.

The possession of these charactertistics puts these 18 trees in a separate class from the others, and the clear recognition of what the characteristics are will greatly simplify our problem and seems to justify the designation of these species as "controlling trees." Unless exactly understood, this term may lead to confusion. Perhaps "potentially controlling trees" would more accurately describe what is meant.

Their mere presence in a stand does not necessarily make them controlling. If one or more of these species is present in such numbers as to be the leading species, no confusion can arise, for their mere numbers make them a controlling factor, and their silvical characteristics reenforce and strengthen their power of control. When less numerous, the question whether or not a particular species is one of the controlling factors depends upon a careful consideration of how many trees there are of each species and of the effect likely to be produced upon the stand by the other controlling factors in that stand.

The chief silvical characteristics which under certain conditions may make these species controlling factors in management are:

(1) Adaptability to certain sites;
(2) Tolerance of shade;
(3) Power of abundant reproduction by seed;
(4) Power of abundant reproduction by sprouts or by root suckers;
(5) Rapid growth.

Of the species possessing one or more of these silvical characteristics, there are listed as controlling trees only those which are actually found, in some stands in the white-pine region, in sufficient numbers to become a controlling factor in those stands. What constitutes sufficient numbers is, of course, a matter of opinion upon which individual foresters may differ. That of the present writer will appear later in the suggestions for management of each of the stands now under consideration.

The list given below includes 18 species falling within the limitations above described. They may fairly be called controlling trees of the white-pine region. In a table which follows the list these species are shown again, grouped under the silvical characteristics which determined their inclusion in the list. This is followed by a brief statement for each species of the conditions under which the potentially controlling trees may become actual controlling factors in management in individual stands in the white-pine region.

In the suggestions for management which follow later all other species are disregarded or are given only the most general consideration.

## CONTROLLING TREES OF THE WHITE-PINE REGION AND THEIR CHIEF SILVICAL CHARACTERISTICS.

### CLASS I: SPECIES THAT ARE FAVORED FOOD OF THE GIPSY-MOTH LARVÆ IN ALL THEIR STAGES.

**Aspen** (*Populus tremuloides* Michx.).
**Aspen**, Large-tooth (*Populus grandidentata* Michx.).
**Beech** (*Fagus atropunicea* [Marsh.] Sudw.).
**Birch**, Gray (*Betula populifolia* Marsh.).
**Oak**, Scrub (*Quercus pumila* [Marsh.] Sudw.).
**Oak**, Black (*Quercus velutina* Lam.).
**Oak**, Red (*Quercus rubra* Linn.).
**Oak**, Scarlet (*Quercus coccinea* Muench.).
**Oak**, White (*Quercus alba* Linn.).

### CLASS II: SPECIES THAT ARE FAVORED FOOD OF THE GIPSY-MOTH LARVÆ AFTER THE EARLIER LARVAL STAGES.

**Chestnut** (*Castanea dentata* [Marsh.] Borkh.).
**Hemlock** (*Tsuga canadensis* [Linn.] Carr.).
**Pine**, Pitch (*Pinus rigida* Mill.).
**Pine**, White (*Pinus strobus* Linn.).

### CLASS III: SPECIES THAT ARE NOT PARTICULARLY FAVORED, BUT UPON WHICH A SMALL PROPORTION OF THE GIPSY-MOTH LARVÆ MAY DEVELOP.

**Maple**, Red (*Acer rubrum* Linn.).
**Maple**, Sugar (*Acer saccharum* Marsh.).

### CLASS IV: SPECIES THAT ARE UNFAVORED FOOD OF THE GIPSY-MOTH LARVÆ.

**Ash**, White (*Fraxinus americana* Linn.).
**Cedar**, Red (*Juniperus virginiana* Linn.).
**Cedar**, White (*Chamaecyparis thyoides* [Linn.] B. S. P.).

*Chief silvical characteristics of controlling trees of the white-pine region.*

| Gipsy-moth caterpillar food class. | 1. Adaptability to certain sites. | 2. Tolerance of shade. | Power of abundant reproduction— | | 5. Rapid growth. |
|---|---|---|---|---|---|
| | | | 3. By seed. | 4. By sprouts or by root suckers. | |
| I | Aspen | | Aspen | Aspen | Aspen. |
| | Aspen, Large tooth | | Aspen, Large tooth | Aspen, Large tooth | Aspen, Large tooth. |
| | | Beech | | Beech | |
| | Birch, Gray | | Birch, Gray | Birch, Gray | Birch, Gray. |
| | Oak, Scrub | | | Oak, Scrub | |
| | | | | Oak, Black | |
| | | | | Oak, Red | |
| | | | | Oak, Scarlet | |
| | | | | Oak, White | |
| II | Chestnut | | | Chestnut | Chestnut. |
| | Hemlock | Hemlock | | | |
| | Pine, Pitch | | Pine, Pitch | | |
| | Pine, White | Pine, White. | Pine, White | | Pine, White. |
| III | Maple, Red | | | Maple, Red | |
| | Maple, Sugar | Maple, Sugar | | | |
| IV | Ash, White | | Ash, White | Ash, White | Ash, White. |
| | Cedar, Red | | | | |
| | Cedar, White | | | | |

## CONDITIONS UNDER WHICH POTENTIALLY CONTROLLING TREES OF THE WHITE-PINE REGION MAY BECOME ACTIVE CONTROLLING FACTORS IN MANAGEMENT.

### THE ASPENS.[1]

The aspen and large-tooth aspen, if few in number in a stand, may be disregarded. They will not control the form of management; that is, they may be cut or left according to the owner's preference. If very numerous or if in pure stands they can not be disregarded, and they become controlling factors because of their rapid growth and power of abundant reproduction by root suckers.

Even if not numerous in the stand then under consideration, these species may be controlling factors in management in that stand if there are numerous seed trees near by, or if the stand contains relatively large areas of bare mineral soil or has recently been burned over. This is because of their power of abundant reproduction by seed and their ability to germinate on such sites.

### BEECH.

The power to survive under dense shade and to reproduce vigorously from root suckers makes the beech a controlling factor in management of stands where it is found in sufficient numbers. It sprouts from the stump, but these sprouts seldom amount to anything. In the southern part of the white-pine region beech reproduction is chiefly by root suckers. In the northern part it can be more easily eliminated from stands if this is desired, because there it reproduces chiefly from seed.

### GRAY BIRCH.

Many stands of gray birch, covering in the aggregate large areas, are found throughout the white-pine region. They are characteristic of old pastures, and the rapid growth and the power of abundant reproduction of this species, both by seeds and by sprouts, make it an exceedingly difficult and expensive undertaking to eliminate it or even to alter materially the composition of stands in which it is numerous. Under such conditions it becomes a controlling factor in management and can not be disregarded, if success is expected.

### SCRUB OAK.

This species (*Quercus pumila* [Marsh.] Sudw.) occupies large areas of so-called waste land, especially in southeastern Massachusetts. The sites on which it occurs are often too poor for agricultural crops but excellent for tree growth, which in most cases originally occupied them. The seeding and sprouting capacity of the species and its ability to grow in soil too poor for other oaks have enabled it to maintain itself and to increase the area occupied in spite of cutting and fires which have reduced the proportion of the pine originally present. These characteristics make the species, although seldom fit even for saleable firewood, a controlling factor in management when it is found in sufficient numbers.

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[1] For further details see Forest Service Bulletin 93, The Aspens, Their Growth and Management, by W. S. Weigle and E. H. Frothingham.

### BLACK, RED, SCARLET, AND WHITE OAKS.

These oaks should be confined to soils best adapted to their requirements. Such soils are often suitable for agricultural crops. Sites too rough for agriculture are often excellent for hardwoods other than oak or for white pine. To one knowing nothing about it, it sounds very simple to cut the oaks and plant pine, but the power of abundant reproduction by sprouts, common to these species, makes such a conversion a difficult and expensive proceeding, and owing to this their presence in a stand in sufficient numbers makes them controlling factors in management.

### CHESTNUT.

Chestnut has an intolerance of shade which prevents the seedlings from coming up in any dense shade, even that of sprouts of the same species. The supply of seed is usually scanty, owing to the general practice of gathering the nuts. These facts, and its power of abundant reproduction by sprouts and their very rapid growth, all unite to make sprout growth the usual form in which the tree is found in this region.

It does not need a rich soil, but to make good growth requires depth and a soil whose physical structure insures good drainage. It will succeed on soils too dry for beech or maple. There are large areas of glacial drift throughout the white-pine region well adapted to chestnut. It is never found in stands 100 per cent pure, but mixed hardwood stands with 60 to 80 per cent of chestnut are not uncommon. When so numerous on suitable sites its sprouting capacity and rapid growth make this species a controlling factor in management.[1]

### HEMLOCK.

That portion of New England now infested with the gipsy moth is not especially adapted to hemlock, which reaches its largest size in the coves of the mountains of West Virginia, North Carolina, and Tennessee. In the white-pine region pure hemlock stands are rare, and the proportion of the area now bearing any hemlock is small.

It is confined, as a rule, to moist ravines and cool slopes, where it should be permanently retained, for its adaptability to such sites makes it there a controlling factor. For the protection of water-sheds which should never be denuded, hemlock is especially well suited. Where the retention of hemlock is desired, stands should never be clear cut but should be handled on the selection system, described later. (See p. 44.)

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[1] The susceptibility of chestnut to the chestnut bark disease is another factor that must be considered in this connection. See comment on page 40.

Its tolerance of dense shade and its ability to grow vigorously after a long period of suppression may make hemlock a controlling factor when found as an understory in any stand with an overstory of other species. If fires are excluded, and the trees composing the overstory are not removed too suddenly, hemlock will eventually occupy the site. If this too sudden removal is intentionally prevented by careful management, the understory of hemlock will materially increase the yield from the area occupied and will protect and enrich the soil, but its growth is so extremely slow that, where the object of management is timber production, hemlock should never be grown as the principal crop on level land with soil suitable for agriculture, or on sites suitable for tree species of greater value and of more rapid growth.

### PITCH PINE.

Pitch pine is very intolerant of shade and soon dies if overtopped. It is fire resistant; even the seedlings will survive a fire which would kill any other New England species. It bears large crops of seed every year and begins to form cones at an early age. It withstands drought well, and its seedlings require no shade. It does best on good soil, but can not there compete with less intolerant or with more rapidly growing species. Scattered specimens may be found on such sites, but there it is not a controlling tree. Pure stands are found only on sites either too poor or too exposed for other species or so frequently fire swept that other species have been eliminated. When found on such poor sites pitch pine is absolutely controlling, for no other native species will grow there. When mature, the stand may be clear cut and the site planted to pitch pine, or seed trees may be left about 10 per acre, or the area may be seeded artificially.[1] On the better sites pitch pine will be a controlling tree only if, and as long as, the fire hazard remains. When this is removed, more valuable species may return very gradually if seed trees are within reach, or they may be introduced by planting. It is believed that the presence of scrub oak on fire-swept soils is a safe indication that the site occupied is not of the poorest class.

Within the white-pine region pure stands of pitch pine are now found chiefly in the following places: In Maine, south and west of the

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[1] 1912 Conn. State Foresters Report, p. 472, Plot No. 3, 1.3 acres of "natural sand plain" at Windsor. Seed sown on cultivated strips, 1½ feet broad and 4 feet apart. Seed slightly covered by brushing the surface. Two pounds of seed per acre on one-half of the area; one pound per acre on the other half. Conclusion after 10 years: "A stand of this species may be successfully established in this manner. Two pounds of seed per acre gives too dense a stand; 1½ pounds would be sufficient."

Androscoggin and along the Saco River;[1] in New Hampshire on the Saco watershed, especially around Silver Lake in Madison and near Ossipee Lake;[2] in Massachusetts on Cape Cod. It is also found in Connecticut, outside the white-pine region, on the sand plains of the lower Connecticut Valley.[3]

### WHITE PINE.

White pine is adaptable to many sites, dry or moist, poor or good. Its seedlings do not often survive if they germinate either in the open or under a heavy shade. They do best under a light shade, such as that of gray birch or aspen, and will persist there until the older hardwood trees die or are passed by the pine. These qualities and its very rapid growth make white pine a controlling tree when its seedlings occupy the ground beneath gray birch or aspen, or when older pines are mixed with other hardwoods of less or of equal height. Unlike the pitch pine, abundant seed crops of white pine are produced only at irregular intervals of four to seven years. This irregularity and the generally unsuccessful attempts to secure natural reproduction make white-pine seed trees on or near the lot of much less practical importance than would be supposed from reading existing literature on the subject, though if such seed trees are present, and the stand is cut in a white-pine seed year, a new stand of white pine may occasionally be secured by natural seeding.[4]

### RED MAPLE.

Red maple is found throughout the white-pine region, often pure in swamps or scattered there, or even on dry uplands. Reproduction is good, for this species produces abundant seed crops every year which ripen in the spring, and when cut, the stumps sprout vigorously. In the wettest swamps it grows more rapidly than any other hardwood species and when found pure on such sites is a controlling tree. Such stands should be managed to produce cordwood, by clear cutting, with sprout reproduction, on a rotation of 30 to 35 years.

### SUGAR MAPLE.

In eastern Canada and in the northern hardwoods region of New England sugar maple is an important species. In the white-pine region only scattered individuals are found except in southern Maine and southern New Hampshire. There the tree is more common in the woods, and some "sugar orchards" are found. Its seed ripens in October. Some is produced nearly every year, but full crops are borne only at intervals of three to five years. Next to beech, sugar maple is probably the most tolerant of American hardwoods. In youth shade is an advantage, but at maturity full light is not detrimental. It grows slowly and is a strong, vigorous, aggressive species able to hold its own with any trees on soil suited to it, but it is not a "poor-land" tree. It does not grow in swamps. It prefers a fresh, well-drained soil, and in New England finds ideal conditions at moderately high elevations on cool northerly slopes. Its adaptability to such sites and to soils containing lime, together with its tolerance of dense shade, make it a controlling tree when found there in sufficient numbers, either in the main stand or in the young growth beneath it.

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[1] Maine Forest Commissioners 1906 Report, page 9.

[2] N. H. Forestry Commission Report for 1903–4, pages 61, 68.

[3] Hawley & Hawes, Op. cit., p. 42.

[4] The susceptibility of white pine to the white-pine blister rust is another factor that must be considered in this connection. See comment on page 40.

### WHITE ASH.

White ash resembles hemlock in the ability of its seedlings to start in dense shade and to respond well when released, but the length of time it can stand suppression is much less than that of hemlock. Like other species, white ash is more intolerant on poor than on good sites. After the pole stage it can endure only a moderate amount of shade. It is found, except on poor, dry sites, throughout New England, but is of greater importance in the northern hardwoods and sprout hardwoods regions which adjoin the white-pine region at the north and south. White ash occurs usually as scattered individuals in second-growth mixed hardwood stands on the richest soils now forested. It is not a swamp tree, but requires deep, fertile, and well-drained soils, with abundant moisture available near the surface. Gentle north or east slopes are especially favorable sites.

It sprouts vigorously when cut, seeds freely about every other year, with exceptionally heavy crops at intervals of three to five years. It starts well in openings in broken hardwood stands and also on pine needles under pure second-growth white-pine stands, if not too dense. It also seeds in well after a fire, if the site is sufficiently moist and seed-bearing trees are near. It grows more rapidly than the other hardwoods with which it is usually found and occasionally forms 25 per cent or more of mixed second-growth hardwood stands along streams or lakes on rich, moist, well-drained soil. Under these circumstances its adaptability to the site, its rapid growth, and its power of abundant reproduction by seed and by sprous make it a controlling tree. Such stands may be clear cut if they offer an open seed bed, or they may be handled on the shelterwood system if the stands are dense.

### RED CEDAR.

Red cedar is widely distributed in the eastern United States, but only in the Southeast, on good soil, is it now found in the quality and sizes which give it its greatest value. In New England it ranges from Augusta, Me., and from southern New Hampshire through Massachusetts and Rhode Island into Connecticut. It is charactertistic of old fields and pastures, the stands varying from a few scattered trees to dense pure stands, and it is also found in mixture with gray birch and with other trees.

Within the white-pine region thousands of acres in the aggregate are covered by this typical growth, which can not be cut profitably until the cedar is large enough for posts and the birch for cordwood. On such sites, when found in sufficient numbers, and on rock covered with not more than 6 inches of soil, where no other tree can grow, red cedar is a controlling tree.

When cut from such rocky sites it should be replaced by seeding or by planting 4-year-old red-cedar stock, three times transplanted in the nursery.

On old fields and pastures thinning is not recommended, even in dense stands, as the increased growth is so slow that thinning will not pay.

The general object of management should be to replace the cedar with more rapidly growing species. When material is large enough to sell, stands should be clear cut and planted. In the meantime open stands of cedar not ready for clear cutting should be filled by planting white or red pine, and mixed stands handled as suggested for the stand at Amesbury, Mass., described later. That stand is characteristic old-field growth, with a small percentage of red cedar.

### WHITE CEDAR.

This species, *Chamaecyparis thyoidse* (Linn. B.S.P.), must not be confused with the other of the same common name, *Thuja occidentalis* Linn., also found in New England and often called arborvitæ. Arborvitæ is rarely seen south of Boston, and Chamæcyparis perhaps as rarely north of that city. Although not unknown in southern Maine and southern New Hampshire, it is not found in commercial quantities in the white-pine region except in certain swamps within 20 miles of the coast in Massachusetts, Rhode Island, and Connecticut.

It is found pure and also mixed with red maple. Many swamps in which it formerly grew have been cleared and converted into cranberry bogs, and others not suitable for cranberries will probably eventually be drained and used for other agricultural crops.

Until this is done no attempt should be made to eliminate white cedar from such sites for, in spite of its very slow growth, it is there, on account of its adaptability to the site, a controlling tree. Its cones mature at the end of the first season and persist through the winter. White cedar readily starts from seed and should be managed by clear cutting in small groups or in strips not wide enough to offer much danger from windfall.

## TYPICAL STANDS.

Having now considered the factors involved in any attempt to control the gipsy moth by forest management, let us see how they apply in typical stands.

The stands previously mentioned will be discussed in the order given on page 19, and readers should remember that any general statement or suggestion referring to a class is intended to apply to that class as represented in the stand then under consideration and may not be applicable to the species composing the class when found in other stands, especially if they occur there in different proportions.

### STAND AT DOVER, MASSACHUSETTS.

#### THE MANAGEMENT OF A TYPICAL MIXED OAK STAND WITH ABOUT FOUR-TENTHS WHITE OAK.

The woodlot contained eight species on 1 acre, but since red, white, and black oak together constituted 94 per cent of the whole, it may be considered from the standpoint of management as a mixed oak stand. It is on good soil, a light, brown, sandy loam, not as deep as that of the Exeter plot, but moist and well drained. It is underlain by gray granite ledges which outcrop in a few places but occupy less than 1 per cent of the area. The surface is free from loose stones, but there is one large granite boulder. The trees averaged 4.9 inches in diameter breast high and, excepting the white pines, were about 30 years old.

The infestation by the gipsy moth was first found near this lot in 1905, and in 1913 the egg clusters present on this area were estimated at 15,000 per acre, and defoliation was heavy.

If the stand were not infested it could be handled as a sprout forest[1] on a rotation of 70 to 80 years, with several thinnings. The thinnings should yield enough cordwood to pay for them, and the final product, cut 40 or 50 years from now, would be good oak timber.

It has been the practice in eastern Massachusetts, in town, State, and Federal work, and by some owners of heavily infested stands of this character, to remove all dead trees and as much undergrowth as possible and make a heavy thinning. This has been done to simplify *spraying*, which is effected by a high-power sprayer, resembling in size and general appearance the watering carts used in city streets. Spraying costs from $8 to $15 an acre, which must be spent each year while the infestation continues heavy and is efficacious in stopping defoliation at the stage reached when the spraying is done. It generally reduces the number of caterpillars but cannot prevent all damage by them, for its effect is dependent upon the leaves being eaten by the caterpillars.

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[1] Simple coppice system.

Management for moth control may be attempted by making one cutting or by successive cuttings.

*One cutting.*—The expense of spraying may be entirely avoided in stands of this character by clear cutting, leaving conifers if desired, and planting red or white pine. If this is done it must be followed by several *cleanings* (removing the hardwood sprouts), or the caterpillars in their early larval stages may feed on the hardwood foliage and in their later stages attack the pine.

It should be remembered, however, that the gipsy moth increases in numbers less rapidly on young hardwood sprouts than on larger trees of the same species, whether these are of sprout or of seedling origin. When the object of management is moth control, this less rapid increase, of course, affects the number of cleanings which are needed in young sprout hardwood stands after cutting.

After various experiments the conclusion has been reached that cleanings in the first, third, and fifth years following a clear cutting in hardwoods will be ample to insure protection to small planted pines and that in many cases the interval between cleanings may safely be increased to three years, and the first one postponed until the second year after the original cutting.

From purely silvicultural considerations the presence of hardwood sprouts on the ground during the first summer after clear cutting is likely to be beneficial to small planted pines by providing some shade, and a cleaning in the second and another in the fourth or fifth year following clear cutting would prevent the small pines from being killed out or so suppressed that their growth would be seriously checked.

From considerations both of silviculture and of moth protection an owner planning to cut clear a mixed oak stand and to plant pine should be prepared to make two and perhaps three cleanings, and should realize that even more may be necessary.

The product of clear cutting on this lot would be about 20 cords of good cordwood per acre, which is practically unsalable in this locality because of the great amount of cutting now being done. If sold, the most that can reasonably be expected for it is $2.50 per cord on the lot. The cost of cutting should not exceed $1.25 per cord. The planting, including stock, will cost from $12 to $15 per acre.

The cost of a cleaning made the first year after cutting will be less than one made the second year, because of the great difference in the size of the sprouts. If made the first year it will require seven or eight hours' labor of one man. If made the second or third year, it may well take 10 or 11 hours. Great care must be used to avoid damage to the small planted pines.

Removing sprouts by mowing is especially dangerous to young growth, wild or planted, which it is desired to retain, and any form of cutting is less effective and must be repeated more often than breaking or pulling the sprouts from the stump. Pounding them off with the poll (back) of an ax is especially desirable, and the first year after trees are cut sprouts may be removed by trampling around the stump. This method is especially successful with oak sprouts and is not very hard on the feet if heavy shoes are worn.

The time of year when trees are cut has an important bearing on the number and vigor of sprouts which follow, and the same is true of removing sprouts. The best time undoubtedly varies with the species and locality, even in an area as small as New England, but no precise information on this subject is available. Speaking generally, it may be said that trees cut in the summer have less vigorous sprouts than those cut in May or June. The same conditions apply to sprouts. If these are removed in July or August those which follow are smaller and more tender than those which follow sprouts removed earlier in the season and are likely to be killed or damaged by frost. The result of clear cutting, planting, and cleaning in this stand, if fires are excluded, would be a pure stand of young pine on good soil, which should grow rapidly, yield a high return, and be secure against gipsy-moth attack.

The owner of this stand, like many others in the infested region, was unwilling to make a clear cutting but very anxious to control the gipsy moth. In such cases the plan offering the best chance of eventually controlling the gipsy moth is to begin the gradual conversion of the stand from hardwoods to pine by successive cuttings.

*Successive cuttings.*—The first cutting, to be made at once, should remove all dead, dying, defective, or suppressed trees. All Class I trees (most favored food of the caterpillar) should be cut as heavily as is possible without exposing the ground too much. Many trees of this class must be left, but they should be, as far as possible, thrifty trees of seedling origin, and a particular effort should be made to reduce the number of white oaks.

The Class II trees (favored food after the earlier larval stages) will be favored in this cutting. On this lot they were white pines large enough for seed trees and so especially desirable.

The Class III trees (not particularly favored food) will also be favored in the first cutting. On this lot these were only a few red maple and pignut hickory.

The Class IV trees (unfavored food) will not be cut, even if defective or suppressed. On this lot they were white ash.

In a stand as dense as this (500 trees per acre) about 60 per cent of the total number present should be removed. The result upon the actual stand now under consideration, of following either of the two plans of cutting proposed, appears clearly in the following table:

*Stand and cutting table, Dover, Mass. Mixed oak stand, four-tenths white oak.*

| Trees which control if in sufficient numbers. | Original stand. | | | Number per acre left under two plans proposed. | | |
|---|---|---|---|---|---|---|
| | Trees which control on this lot. | Other species present. | Number per acre. | 1. Radical conversion—one cutting (now). | 2. Gradual conversion—successive cuttings. First (now). | 2. Gradual conversion—successive cuttings. Second (in 5 to 10 years). |
| Class I: | | | | | | |
| Red oak | Red oak | | 229 | | 130 | |
| Black oak | Black oak | | 59 | | 36 | |
| White oak | White oak | | 193 | | 28 | |
| Gray birch | | Gray birch | 1 | | | |
| Class II: | | | | | | |
| White pine | | White pine | 17 | 17 | 17 | 17 |
| Class III: | | | | | | |
| Red maple | | Red maple | 5 | | 2 | 2 |
| | | Hickory | 3 | | 2 | 2 |
| Class IV: | | | | | | |
| White ash | | White ash | 3 | | 3 | 3 |
| | | | 510 | 17 | 220 | 24 |

The lot should be planted at once with some moth-resistant species. Red or white pine, or a mixture of both, may be used, 1,000 to the acre, with entire confidence.

The site as a whole is too dry for white ash, but a few, 25 or 50, could be planted at the lowest part of the lot with benefit to its eventual moth-resistant character.

Cleanings will be necessary for at least five years, as in the case of clear cutting. (See p. 29.)

The second cutting should be made just as soon as the trees planted are established and have gained a decisive lead over the sprouts from stumps of trees cut. This would be not less than five years after the first cutting. If it were delayed until 10 years after, the planted trees would probably be secure against being overtopped by sprouts from the second cutting. If cut after five years, a cleaning in the second and another in the fourth year would probably be necessary. The second cutting should remove all remaining Class I trees of the original stand, leaving the Class III and Class IV trees. The white pines of the original stand will be large enough to cut profitably at this time, but might better be left as standards to supply some extra-large material in the final cutting of the planted stand.

The product of the first cutting will be cordwood, about 8 or 9 cords per acre, worth not more than $2.50 per cord on the lot. In addition there will be 3 or 4 cords of poor cordwood, probably worth about what it cost to cut or a little less. The product of the second cutting will depend upon when the cutting is made. There will be only cordwood unless the cutting is delayed for 40 to 50 years, or until the stand is 70 to 80 years old, in which case material of larger dimensions can be obtained.

After the second cutting some additional planting will probably be necessary to replace trees of the first planting which have died or have been destroyed in the second cutting. The number required should not exceed 300 per acre.

The cost of the first cutting will be about $1.50 per cord and of the second about $2 per cord.

The first planting, including stock, will cost about $15 per acre, and the second planting $4 or $5 per acre. The higher cost, as compared with planting after clear cutting, is due to the need of going over the ground twice and to the care necessary to avoid damage to young growth when the two plantings are made.

A cleaning the first year after the first cutting will require four or five hours' labor per acre of a careful man; and the cost will depend, of course, upon whether the owner does the work himself, has such a man available, or must employ one especially for the work.

Later cleanings after the first cutting and the two biennial cleanings after the second cutting are each likely to require somewhat more time, as greater care will be needed to avoid doing damage to planted stock, but six to eight hours per acre should suffice.

The result will be, if fires are excluded, a moth-resistant stand of a composition dependent upon the species selected for planting.

The cost of either plan would be heavy, and for most owners, especially if applied to large areas, it would be prohibitive. But where the infestation is severe either plan of management offers improved conditions at less expense than spraying for five years at $15 per acre.

With a good cordwood market the first plan, clear cutting, should yield a slight margin of profit over all costs. The second plan involves a considerable investment without any net returns up to the time the conversion from a susceptible to a resistant stand is completed.

Where the moth is present in large numbers this should be compared with the cost of spraying and creosoting, and the net cost of converting the stand regarded as the price the owner has paid for the satisfaction of not denuding his land, for relief from annual expenses, the results of which are only palliative, and for future insurance against damage by the gipsy moth.

The possibility of control by management, without planting, is the object of experiments now in progress.[1] Pending their conclusion, it is believed that sufficient information has been given in the foregoing to guide owners of stands of this character who wish to do something at once.

Of the two plans outlined, the first, clear cutting and immediate planting of the whole area, is preferable from considerations of forest management, of moth control, and of minimum expense. Economic conditions preclude the expectation of its general adoption in the near future, but it is strongly recommended to owners willing to meet the expense.

Others must face the fact that they can not at present expect to secure moth control by forest management.

### STAND AT EXETER, NEW HAMPSHIRE.

#### THE MANAGEMENT OF A TYPICAL MIXED OAK STAND WITH THREE-TENTHS WHITE OAK.

The woodlot of 2.5 acres contained 15 species, but since red, white, and black oak together constituted 87 per cent of the whole, it may be considered from the standpoint of management as a mixed oak stand. It is on good agricultural soil, a dark, brown, sandy loam, deep, moist, and well drained. The trees averaged 6.1 inches in diameter breast high and about 35 years old.

The surrounding region had been infested with the gipsy moth since 1908, the infestation coming apparently from the northeast. In 1913 the count on this lot disclosed 949 egg clusters per acre. There was very severe defoliation, but it was not all due to gipsy-moth caterpillars. They were responsible for part of it, but a very large part was the work of brown-tail and forest tent caterpillars.

If the stand were not infested, it could be handled like that at Dover, as a sprout forest.

If the owner wishes to attempt to control the gipsy moth by forest management, the two methods suggested for Dover will be applicable, with certain modifications.

*One cutting.*—If cut clear and planted, the products will be less, because, though the trees averaged a little larger, there were only three-fifths as many—300 per acre. The product will probably be about 20 cords of good cordwood per acre, worth, as this lot is situated, about $3 per cord on the lot.

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[1] See also, Results of Experiments in Controlling the Gipsy Moth by Removing Its Favorite Food Plants. By A. F. Burgess and D. M. Rogers, Journal of Economic Entomology, Vol. VI, pp. 75 to 79 (1913).

*Successive cuttings.*—If the plan is adopted of making a gradual conversion of the stand from hardwoods to pine, the first cutting may be made on the same general plan as at Dover, but should remove not over 40 per cent of the total number of trees present, because this stand is much less dense.

The result upon this stand appears in the following table:

*Stand and cutting table, Exeter, N. H. Mixed oak stand, three-tenths white oak.*

| Trees which control, if in sufficient numbers. | Original stand. | | | Number per acre left under two plans proposed. | | |
|---|---|---|---|---|---|---|
| | Trees which control on this lot. | Other species present. | Number per acre. | 1. Radical conversion—one cutting (now). | 2. Gradual conversion—successive cuttings. | |
| | | | | | First (now). | Second (in 5 to 10 years). |
| Class I: | | | | | | |
| Red oak | Red oak | | 89 | | 64 | |
| Black oak | Black oak | | 77 | | 62 | |
| White oak | White oak | | 84 | | 12 | |
| Gray birch | | Gray birch | 1 | | | |
| Large-tooth aspen | | Large-tooth aspen | 1 | | | |
| Beech | | Beech | 2 | | | |
| | | Apple | (1) | | | |
| Class II: | | | | | | |
| White pine | | White pine | 11 | 11 | 11 | 11 |
| Pitch pine | | Pitch pine | (1) | (1) | (1) | |
| Class III: | | | | | | |
| Red maple | | Red maple | 20 | | 13 | 13 |
| | | Yellow birch | (1) | | (1) | (1) |
| | | Black birch | 1 | | 1 | 1 |
| | | Hickory | 2 | | 2 | 2 |
| | | Black cherry | (1) | | (1) | (1) |
| | | Elm | (1) | | (1) | (1) |
| Class IV: | | | | | | |
| None | | | | | | |
| | | | 291 | 11 | 166 | 28 |

[1] Less than one tree per acre.

Planting should at once follow the first cutting. Red or white pine, 1,000 to the acre, may also be used here, but a larger part of the area is suitable for white ash. It is possible that on sites of this character a mixture of 5 per cent of tulip tree or white ash with the pine would be advantageous. White ash may also be planted pure on deep moist soils in areas not exceeding one-half acre in extent.

The time of making the second cutting and the need of a second planting will be determined by the same considerations as at Dover.

The product of the first cutting will be cordwood, 7 or 8 cords per acre, and, unless tops and limbs are burned, 3 or 4 cords of poor cordwood worth less than it cost to cut.

The costs of cutting and of planting should not differ much from those at Dover, and for the same reasons which apply there the first of the two plans proposed is preferable from considerations of forest management, of moth control, and of minimum expense.

### STAND AT WAREHAM, MASSACHUSETTS.

### THE MANAGEMENT OF A TYPICAL MIXED OAK STAND WITH ABOUT TWO-TENTHS WHITE OAK.

The woodlot contained nine species, but since scarlet, white, and black oak together constituted 83 per cent of the whole, it may be considered from the standpoint of management as a mixed oak stand.

It differed from the mixed oak stands at Dover and Exeter in that it was 60 years old, scarlet oak was present and formed over 50 per cent of the stand, white pine was more numerous, the gipsy-moth infestation was very light, and a dense growth of young white pine was already present on parts of the lot.

The soil is a brown, medium-textured, sandy loam with a sprinkling of fine gravel. The surface 2 or 3 inches is gray. The soil is deep and naturally well drained.

On 5.4 acres, where all trees were measured, those trees over 2.5 inches in diameter averaged only 7 inches in diameter breast high. The stand was even-aged and was cut clear about 60 years ago. Many of the larger trees were stagheaded (dead in the tops).

Although the gipsy moth had been present at least since 1911, the infestation in 1913 was very light, averaging only about 12 egg clusters per acre, and the damage done by the caterpillars was not noticeable. The defoliation due to forest tent and geometrid caterpillars was much more severe.

The owner is a manufacturing corporation which uses the lot as a source of supply for material for repairs to its plant.

This cutting of the larger hardwood trees undoubtedly accounts for the low average diameter of the stand, and the practice of making small openings probably explains the presence and location of the dense growth of small white pine found on the lot.

This land is well suited to growing potatoes, berries, and other garden truck, but if it is to be kept as a woodlot the stand should be converted from hardwoods to pine, wholly apart from considerations due to possible damage by the gipsy moth. This can be accomplished by clear cutting in one operation or in two successive operations.

*One cutting.*—If the stand is cut clear in one operation, all hardwoods should be removed and especial care used to prevent, as far as possible, damage to the young pine already present, which should be supplemented by planting red or white pine on areas not sufficiently stocked.

Cleanings will be needed, about three in all, made every two years, to release the young pine from the hardwood sprouts which are useful at first in providing shade, but, if not removed, will in a short time kill out much of the pine. If cut clear, the hardwoods would yield about 20 cords per acre, but as this lot is maintained for a special purpose, the product should be as far as possible cut in such sizes as the owner requires and the balance put into cordwood. Owing to the care required to avoid damage to young growth, the cost of cutting will be high, perhaps $40 per acre. The cost of necessary planting (400 trees per acre) will average $6 per acre. The three cleanings will require 8 to 10 hours' labor of one man per acre. The result will be a pure stand of young pine on good soil, which, if fires are excluded, should grow more rapidly and yield a greater quantity of wood of higher value than the stand which it replaced, and which in addition will be secure against gipsy-moth attack.

*Successive cuttings.*—If the plan is adopted of gradually converting the stand from hardwoods to pine, two cuttings should be made. The first cutting, to be made at once, should remove all dead, dying, defective, and suppressed trees. As the gipsy moth is not present in large numbers, the heavy cutting of Class I trees (most favored food of the caterpillar) is not as important as in stands already considered, but since there are almost no other trees present except pines, the cutting above described amounts in this instance to practically the same thing as recommending the cutting of Class I trees of the species found on this lot. The object should be to cut as heavily as is possible without exposing the ground too much and to release all pines in danger of suppression.

The hardwoods left should be as far as possible thrifty individuals of seedling origin. All pines likely to make good trees should also be left. About 50 or 60 per cent of the total number of trees present should be removed.

The areas insufficiently stocked should be planted at once with some moth-resistant conifer. The soil is not suitable for any of the resistant hardwoods. Red or white pine or a mixture of both may be used, as on the lots previously considered, with entire confidence. Owing to the young growth of white pine already present, an average of 400 plants per acre for the whole lot will be sufficient.

Cleanings, about three in all, will be necessary every two years, as in the case of one cutting. These will meet all silvicultural requirements.

The second cutting should be made just as soon as the trees planted are established and have gained a decisive lead over the sprouts from stumps of trees cut. This would be not less than five years after the first cutting. If it were delayed five years longer the planted trees would probably be secure against being overtopped by sprouts from the second cutting. If cut after the first five years a cleaning in the second and another in the fourth year would probably be necessary.

The second cutting should remove all remaining hardwoods, leaving only conifers. If at that time a market or use exists for a small amount of low-grade white and pitch pine, those in the original stand might be cut to advantage, leaving an even-aged stand of pine, but it would probably be better to leave them as standards to supply some extra-large material in the final cutting of the planted stand.

The result of following either of the two plans of cutting in this stand appears in the following table:

*Stand and cutting table, Wareham, Mass. Mixed oak stand, two-tenths white oak.*

| Trees which control if in sufficient numbers. | Original stand. | | | Number per acre left under two plans proposed. | | |
|---|---|---|---|---|---|---|
| | Trees which control on this lot. | Other species present. | Number per acre. | 1. Radical conversion—one cutting (now). | 2. Gradual conversion—successive cuttings. First (now). | 2. Gradual conversion—successive cuttings. Second (in 5 to 10 years). |
| Class I: | | | | | | |
| Red oak | | Red oak | (1) | | | |
| Black oak | Black oak | | 24 | | 12 | |
| Scarlet oak | Scarlet oak | | 164 | | 65 | |
| White oak | White oak | | 65 | | 10 | |
| Gray birch | | Gray birch | (1) | | | |
| Class II: | | | | | | |
| White pine | White pine | | 45 | 45 | 43 | 43 |
| Pitch pine | Pitch pine | | 5 | 5 | 3 | 3 |
| Class III: | | | | | | |
| Red maple | | Red maple | 2 | | (1) | |
| Black gum | | Black gum | (1) | | (1) | |
| Class IV: | | | | | | |
| None | | | | | | |
| | | | 306 | 50 | 133 | 46 |

(1) Less than 1 tree per acre.

As to the products of cutting, the same limitations apply that were considered under the plan of clear cutting in one operation. They should be, as far as possible, what the owner requires and the balance put into cordwood. If the products of the first cutting were all cordwood, there would be about 12 or 13 cords per acre of good merchantable wood.

It is believed that with the small white pine already present and the planting provided for above, no additional planting would be necessary to replace trees which may die or which may be destroyed in the second cutting.

The cost of the first cutting will be about $20 per acre and of the second cutting about $25 per acre. The planting suggested, including stock, will cost about $6 per acre. The biennial cleanings after the first and second cuttings will each require five or six hours' labor per acre of a careful man. The cost will, of course, depend upon local conditions. The result will be the same as would be obtained by clear cutting in one operation—a stand of young pine on good soil, which, if fires are excluded, should grow rapidly and yield a greater quantity of wood of higher value than the stand which it replaced, and which in addition will be secure against possible damage by the gipsy moth. Of the two plans suggested, the former, removal in one cutting, is preferable, because costs of cutting and of cleaning will be less, damage to planted stock will be eliminated, and less time will be required to accomplish the conversion of the stand.

The possibility of control by successive cuttings is the object of experiments now in progress on this and other lots. Pending their conclusion, the removal in one cutting is recommended to owners of stands of this character who wish to do something at once.

### STAND AT MEDFIELD, MASSACHUSETTS.

### THE MANAGEMENT OF A TYPICAL MIXED HARDWOOD STAND WITH ONE-TENTH WHITE OAK.

The woodlot contained only six species on 1.3 acres, but the three species of oak and the chestnut together constituted 90 per cent of the whole. Since chestnut, the leading species, formed 52 per cent of the stand and is a controlling tree of Class II (not favored food until after the earlier larval stages) and is present in sufficient numbers, it must be the determining factor in management.

The lot slopes gently to the north and northeast and has good soil, a brown sandy loam, deep, moist, and well drained, and free from stones.

The trees averaged 6.6 inches in diameter breast high, about 40 years old, and 426 per acre.

The gipsy-moth infestation was first found in 1909 in similar growth on the adjoining lot to the east, where, in spite of creosoting by the local moth superintendent, 40 per cent of all trees and 80 per cent of the white oaks had died by 1913. On the lot now under consideration the gipsy-moth infestation in 1913 was very severe, but less than 10 per cent of the trees were dead.

The usual form of management recommended by foresters for a stand of this character is the simple coppice system, using a rotation of about 60 years, with several thinnings. This means merely that the stand is to be cut clear at that age and allowed to reproduce by sprouting, after which thinnings are made if possible to do so without loss. To secure gipsy-moth control this should be modified by discriminating against the oaks and eliminating the white oak, which latter may often be done without harmful effects silviculturally in cases like this where white oak forms only 10 per cent of the stand.

*Successive cuttings.*—As the stand has not been under management and the infestation is heavy, the first cutting, a thinning, should be made at once along the lines indicated above, favoring chestnut and releasing and favoring white pine. Fifty per cent of the total number of trees may be removed without unduly exposing the ground and with real benefit from a general silvicultural standpoint. The result of the thinning described appears in the following table.

*Stand and cutting table, Medfield, Mass. Mixed hardwood stand, one-tenth white oak.*

| Trees which control if in sufficient numbers. | Original stand. | | | Number per acre left under plan proposed. | |
| --- | --- | --- | --- | --- | --- |
| | | | | Gradual conversion—successive cuttings. | |
| | Trees which control on this lot. | Other species present. | Number per acre. | First (now). | Second (in 20 years). |
| Class I: | | | | | |
| Red oak | Red oak | | 91 | 29 | |
| Black oak | Black oak | | 29 | [1] 26 | |
| White oak | White oak | | 43 | | |
| Class II: | | | | | |
| White pine | White pine | | 38 | 32 | |
| Chestnut | Chestnut | | 219 | 105 | |
| Class III: | | | | | |
| Red maple | | Red maple | 6 | 1 | |
| Class IV: | | | | | |
| None | | | | | |
| | | | 426 | 193 | (2) |

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[1] In the cutting actually made on this lot, black oak was favored as an experiment, so the table does not in this respect conform to the practice suggested in the text.

[2] See p. 39, last paragraph.

Planting will not be necessary, but cleanings for at least five years (see p. 29), removing all sprouts of Class I trees, will be of great assistance in reducing the amount of food available for first-stage gipsy-moth larvæ and in maintaining the altered composition of the stand. It should be stated frankly in this connection that the entomologists consider the removal of all oaks and other Class I trees as the safest method to follow in controlling the gipsy moth by limiting its food plants. The foresters, however, who are working on the problem consider this most undesirable from the standpoint of management. Both agree that the help to be expected throughout the infested region from parasites and other enemies and periodical outbreaks of the wilt disease, combined with other measures of control, may eventually cause the gradual subsidence of the gipsy moth to a normal place among other injurious insects.

Under the plan proposed, the second cutting will not take place for about 20 years (the end of the rotation), at which time the stand will be cut clear..

By leaving the chestnut sprouts following the thinning and the final cutting and removing sprouts of oaks or other Class I trees in the cleanings, the representation of trees of this class in the succeeding stand should be much reduced. By continuing the same process through succeeding rotations all Class I trees may be removed, and the conversion to a moth-resistant stand would be complete in 80 to 140 years.

The products of the first cutting will be chestnut posts, worth 10 to 40 cents each, and cordwood, about 10 cords per acre, worth $4 per cord on the lot. In addition there will be about 3 cords of poor cordwood which is unsalable in the region. Unless the owner can use it himself, it would be cheaper to burn the limbs and tops as the cutting proceeds than to pay for cutting and piling this low-grade cordwood and then let it rot in the woods. The products of the second cutting will be chestnut of sizes suitable for poles, piles, lumber, ties, and posts, a few oak ties and some good cordwood.

The cost of the first cutting will be about $40 an acre, which should be slightly less than the amount realized from the sale of the products. The cost of the second cutting will, of course, depend upon conditions at that time, about 20 years hence, but the value of the products to be expected should yield a small profit. It is not likely that the net profit of the first cutting will be sufficient to cover the cost of the cleanings recommended. If these are made the cost should be considered as a premium for insurance against damage by the gipsy moth.

By concentrating our attention upon the gipsy-moth problem we are in danger of forgetting the *chestnut-bark disease* and the *white-pine blister rust*, both also imported from abroad and perhaps even more difficult to control. The chestnut-bark disease is present on the lot now under consideration and generally wherever chestnut is found throughout the region infested by the gipsy moth. On the lot now in question and others like it, where a large percentage of chestnut is present and the control of the gipsy moth is the immediate problem, it is believed to be wiser to use the chestnut as long as it lasts rather than to attempt the expensive experiment of a radical conversion of the whole stand to white pine, with the risk of fire, blister rust, and white-pine weevil. Where chestnut does not occur, as in the stands previously considered, these risks may be necessary. Here they are not.

### STAND AT AMESBURY, MASSACHUSETTS.

#### THE MANAGEMENT OF A TYPICAL STAND OF OLD-FIELD GROWTH OF PINE AND MIXED HARDWOODS WITH ONE-TWENTIETH WHITE OAK.

This lot, used as a pasture until 15 years ago, contained 19 species of trees on 4.2 acres, but 95 per cent of the whole number consisted of the following eight species, in the proportions indicated:

|  | Per cent. |  | Per cent. |
|---|---|---|---|
| Black oak | 16 | Red maple | 10 |
| White oak | 5 | Red cedar | 5 |
| Gray birch | 21 | White ash | 2 |
| White pine | 28 |  |  |
| Pitch pine | 8 | Eight species | 95 |

The other 11 species, some of them important as timber trees and some from the standpoint of moth resistance, were represented on this lot by too few trees to be important in any plan of management.

The soil is good, a brown sandy loam, deep, moist, and well drained, and the lot is level, except for a small area where water stands late into the spring. It is free from rock or loose stones. When the demand for agricultural land increases sufficiently this lot undoubtedly will again be cleared and cultivated. The trees averaged 4.9 inches in diameter breast high, the same as the Dover stand, but this area was poorly stocked, the stand being very dense in some places and much too open in others, with an average of 321 trees per acre. The infestation by the gipsy moth was very severe in 1913. Several of the white pines were almost bare, with the needles eaten back almost to the sheath. Others were from one-half to three-fourths defoliated.

The present growth is very irregular in size, and if the stand were not infested it is not likely that any owner would consider forest management or would cut the lot before 20 years from now, at which time the hardwoods could be cut clear without loss, although the product would be only cordwood. But if management were begun now the object would be to get rid of the less valuable hardwoods, especially gray birch, and release the pine and more valuable hardwoods by thinning.

Since the stand was infested and Class I trees (most favored food of the caterpillars) formed only 45 per cent of the stand, to cut clear now, as was recommended in the stands previously discussed, would be an unnecessary waste of good species well started. Nor can successive cuttings be recommended in stands of this character. If the danger of soil exposure were serious enough to warrant the expense, the Class I trees might be removed in two successive cuttings as previously described; but when, as in this case, 55 per cent of the stand consists of trees in Classes II, III, and IV, the soil exposure, considering the small area involved, would probably not be a controlling factor.

*Gipsy-moth cutting.*—Immediate protection against further damage by the gipsy moth can be secured by what may be called a "gipsy-moth cutting."

In its effect upon tree species which are favored food of gipsy-moth caterpillars this resembles a damage cutting in that silvicultural considerations are wholly disregarded as far as these species are concerned. All Class I trees of whatever species are removed, whether of merchantable size or not. At the same time any dead trees are cut, and a light thinning, combined with a liberation cutting, is made in the trees of Classes II, III, and IV. To be effective this must be followed by planting some moth-resistant species suitable to the site and by cleanings until these are established, probably for at least five years. (See p. 29.) Owing to the great number of very small trees, between 1 inch and 2.5 inches in diameter breast high, the cost per cord will be high and the product poor cordwood, about 7 or 8 cords per acre.

For planting on such sites, red or white pine or a mixture of both is recommended, with white ash in the moister situations. Tulip tree should also do well on sites suitable for white ash, but if used it should be considered as an experiment. Under the conditions obtaining on this lot, planting an average of 600 trees per acre should be sufficient, and the cost will be $8 to $10 per acre.

The possibility of control without removing all Class I trees is the object of experiments now being conducted on this and other lots. Pending their conclusion, the above suggestions are made to guide owners who wish to do something at once. Neither clear cutting nor successive cuttings can be recommended in stands of this age and character, and a gipsy-moth cutting can be recommended only for owners who put gipsy-moth control above all other considerations.

The result of the three plans is compared in the table following.

*Stand and cutting table, Amesbury, Mass. Old-field growth, one-twentieth white oak.*

| Trees which control if in sufficient numbers. | Original stand. | | | Number per acre left under three plans described. | | | |
|---|---|---|---|---|---|---|---|
| | Trees which control on this lot. | Other species present. | Number per acre. | 1. Radical conversion—one cutting (now). | 2. Gradual conversion—successive cuttings. First (now). | 2. Gradual conversion—successive cuttings. Second (in 5 to 10 years). | 3. Gipsy-moth cutting, see p. 41 (now). |
| Class I: | | | | | | | |
| Red oak | | Red oak | (1) | | | | |
| Black oak | Black oak | | 52 | | 27 | | |
| White oak | White oak | | 16 | | 3 | | |
| | | Swamp white oak | 1 | | | | |
| Gray birch | Gray birch | | 68 | | 14 | | |
| Aspen | | Aspen | (1) | | | | |
| | | Apple | 3 | | | | |
| Class II: | | | | | | | |
| White pine | White pine | | 90 | 90 | 90 | 90 | 90 |
| Pitch pine | Pitch pine | | 27 | 27 | 6 | 6 | 6 |
| Chestnut | | Chestnut | (1) | | (1) | | (1) |
| Class III: | | | | | | | |
| Red maple | Red maple | | 33 | | 22 | | 22 |
| | | Black birch | (1) | | (1) | | (1) |
| | | Hickory | (1) | | (1) | | (1) |
| | | Wild red cherry | 2 | | (1) | | (1) |
| | | Elm | (1) | | (1) | | (1) |
| | | Hop hornbeam | (1) | | (1) | | (1) |
| Class IV: | | | | | | | |
| Red cedar | Red cedar | | 15 | 15 | 15 | 15 | 15 |
| | | Butternut | (1) | (1) | (1) | | (1) |
| White ash | White ash | | 7 | 7 | 7 | 7 | 7 |
| | | | 321 | 139 | 187 | 118 | 141 |

[1] Less than 1 per acre.

### STAND AT NORTH BERWICK, MAINE.

#### MANAGEMENT OF A TYPICAL STAND OF NORTHERN HARDWOODS WITH NO WHITE OAK.

This lot, 4 miles from a prosperous manufacturing town, while within the white-pine region, had a stand characteristic of the northern hardwoods region. It contained 14 species of trees on 3.4 acres, but 98 per cent consisted of the following nine species in the proportions indicated:

| | Per cent. | | Per cent. |
|---|---|---|---|
| Red oak | 2 | Black birch | 4 |
| Paper birch | 2 | Yellow birch | 3 |
| Beech | 45 | Hop hornbeam | 16 |
| Hemlock | 4 | | |
| Red maple | 8 | Nine species | 98 |
| Sugar maple | 14 | | |

The soil is a sandy loam, deep and well drained. The surface is very uneven, steep in places and thickly covered with large stones and small boulders.

The trees averaged 6.5 inches in diameter, breast high, but varied greatly in size, the average for the different species ranging from 3 to 15.2 inches, with a few individual trees ranging up to 31 inches in diameter. The gipsy-moth infestation in 1913 was exceedingly light, only one egg cluster per acre, and had not increased much by 1915, although in that year other woodlots in the neighborhood were severely defoliated.

Under present economic conditions the general application of forest management to such lots as this is not to be expected, but the possibility of controlling the gipsy moth by this means is considered here, to complete the comparison between typical stands found within the white-pine region, and for its possible application in special cases. The Class I trees (favored food of the caterpillars) are red oak, paper birch, and beech. Of these beech is the least valuable commercially, unless there happens to be a local demand for the wood, but it is the most desirable from the standpoint of gipsy-moth control. As a result of his observations, Mosher draws this conclusion: "It is evident that the beech must be associated in a mixture with one or more favored species in order that the gipsy moth may reproduce normally."

Anything which adversely affects the normal reproduction of the moth is of value as a control measure. Mosher's conclusion as to beech would place it for purposes of control by forest management among Class III trees, especially if other Class I trees were removed from the stand. It should also be remembered, in this connection, that there is a wide range in susceptibility to gipsy-moth attack, not only between the species in Mosher's four classes, but also between the different species in each class.

*Uneven-aged stands.*—In uneven-aged stands a modified form of the selection system should be used, cutting to a diameter limit of approximately 12 to 14 inches, which limit, however, should not be strictly applied.

Of course, the same treatment can not be applied to even-aged and to uneven-aged stands. The stand now under discussion is of the latter form, which will be first considered.

The *selection system* may be briefly explained as follows: It is the reverse of the clear-cutting systems already described as applicable to stands like those at Dover, Exeter, Wareham, and Medfield. The whole area remains continually covered with trees which, when all ages and sizes are represented, mingled singly or in groups, are called a selection forest.[1] In the selection system of cutting and securing reproduction the cuttings are made annually or at longer intervals, the mature trees being selected and those not mature left. To maintain a stand indefinitely under this system it is essential that no more trees be cut than will equal in volume the growth of wood put on by the whole stand in the year or other interval between cuttings.

In managing old, uneven-aged stands which have not previously been under management, one of the first steps is to decide upon the approximate rotation to use, for example, 100 years, and then to remove as far as is possible, without making too large openings in the crown cover, all trees too large to be grown in that length of time.

In stands like the one under discussion it would be well to do this and also, in the first cutting, to eliminate red oak and reduce as much as is possible, with due regard to silvicultural considerations, paper birch and other intolerant species of Class I trees, which form a very small percentage of the stand and can not maintain themselves in stands with a large percentage of tolerant trees. The cuttings should each be accompanied by a thinning, removing all dead, dying, defective, or suppressed trees, regardless of their species, but leaving any the removal of which would expose the ground too much. The selection cuttings and thinning combined may remove as much as 50 per cent of the original stand, leaving about 200 trees per acre. In this stand the result upon each size class present is shown in the table on page 46. The result upon the representation of each species appears in the following table.

---

[1] See table, p. 46.

*Stand and cutting table, North Berwick, Me. Northern hardwoods stand with no white oak.*

| Trees which control if in sufficient numbers.[1] | Original stand. | | | Number per acre left after cutting described on p. 44. |
|---|---|---|---|---|
| | Trees which control on this lot. | Other species present. | Number per acre. | |
| Class I: | | | | |
| Red oak | | Red oak | 7 | |
| Large-tooth aspen | | Large-tooth aspen. | 2 | |
| Beech | Beech | | 182 | 77 |
| | | Paper birch | 7 | 3 |
| | | Basswood | 5 | 2 |
| Class II: | | | | |
| Hemlock | Hemlock | | 16 | 14 |
| Class III: | | | | |
| Red maple | Red maple | | 33 | 19 |
| Sugar maple | Sugar maple | | 56 | 29 |
| | | Yellow birch | 11 | 7 |
| | | Black birch | 16 | 9 |
| | | Elm | (2) | (2) |
| | Hornbeam[1] | | 66 | 29 |
| Class IV: | | | | |
| White ash | White ash | | 5 | 5 |
| | | Black ash | (2) | |
| | | | 406 | 194 |

[1] A list of controlling trees for the northern hardwoods region would differ from this one, prepared for the white-pine region. See hornbeam above.
[2] Less than one tree per acre.

For effective gipsy-moth control cleanings will be necessary for at least five years (see p. 29), but the expense may be greatly reduced by confining these to the sprouts of all Class I trees cut, excepting the beech, on which, as already stated, the gipsy moth is not likely to reproduce normally, unless beech is in mixture with other favored species.

Another method of controlling sprouts is to turn cattle into a lot to pasture. The practice of pasturing cattle in woodlots is followed by some owners wholly apart from any silvicultural considerations. It had been done on the lot now under discussion, with the result that it was almost entirely free of undergrowth of all kinds. Foresters condemn the practice, for cattle do not always discriminate between sprouts and seedlings or between valuable and worthless species, and the result is a loss of young growth desirable in any form of management and essential to the success of stands managed under the selection system. In stands containing a very large percentage of trees which are favored food of the gipsy-moth caterpillars, which it is desired to replace by planting, carefully regulated pasturing by cattle or by goats might control the hardwood sprouts, if done for several successive seasons after clear cutting and before planting, but there is danger of exposing the ground so much that it would dry out and entail a large loss among the trees when planted. It is not recommended. If done it should be on a small scale, experimentally.

In spite of the large size of some of the trees, the product of the first cutting will probably be chiefly cordwood, as the large trees in such lots are often hollow at the center. If they prove to be sound, and a mill is accessible, they would, of course, be put into logs for sawing. On this lot the actual product of such a cutting as the one just described was 20 cords of cordwood and 2,800 board feet of logs per acre, the whole equivalent to about 25 cords of cordwood.

If the stand remaining can fairly be described as a selection forest, that is, if all ages and sizes within the rotation and diameter limit adopted are sufficiently represented, management may be continued as it was begun on the selection system.

This was the case in the lot now under consideration, as is shown in the following table.

*Stand at North Berwick, Me., typical of an unmanaged or natural-selection forest.*

| Number of trees per acre alive. | | |
|---|---|---|
| Diameter breast high. | Before cutting. | After cutting. |
| *Inches.* | | |
| 1 | 79 | 32 |
| 2 | 98 | 35 |
| 3 | 87 | 29 |
| 4 | 75 | 27 |
| 5 | 48 | 26 |
| 6 | 41 | 21 |
| 7 | 33 | 17 |
| 8 | 31 | 23 |
| 9 | 23 | 19 |
| 10 | 18 | 10 |
| 11 | 12 | 8 |
| 12 | 10 | 6 |
| 13 | 7 | 3 |
| 14 | 7 | 2 |
| 15 | 4 | 2 |
| 16 | (1) | ... |
| 17 | 1 | (1) |
| 18 | 2 | (1) |
| 19 | (1) | ... |
| 20 | 1 | ... |
| 21 | 1 | ... |
| 22 | 1 | ... |
| 23 | (1) | ... |
| 24 | (1) | ... |
| 25 | (1) | ... |
| 26 | (1) | ... |
| 27 | (1) | ... |
| 28 | ... | ... |
| 29 | ... | ... |
| 30 | ... | ... |
| 31 | (1) | ... |
| Total [1] | 579<br>4 | 260<br>1 |
| Total stand | 583 | 261 |
| 1 and 2 inches | 177 | 67 |
| Over 2 inches | 406 | 194 |

[1] Less than one tree per acre of size indicated.

NOTE.—First cutting made to a diameter limit of approximately 12 to 14 inches, which was not strictly enforced. Stand also thinned at the same time to remove dead, dying, defective, and suppressed trees. Red oak eliminated.

It should be remembered that equal numbers in all size classes would not be a sufficient representation to make a many-aged stand a selection forest, in the sense that that term is used here, and that where suppressed trees have been removed equal sizes may be roughly accepted as an indication of equal ages, although a wide variation actually exists in these respects. To insure the perpetuation of a selection forest managed on the selection system there must be a much greater representation of the smaller than of the larger trees. Theoretically, if a rotation of 100 years is adopted and cuttings are planned to be made every 10 years, the trees should be divided into 10 classes, each of which should occupy one-tenth of the available ground area and crown space.

In stands other than that now under consideration, it might well happen that the stand remaining after the cuttings and thinning had been made could be described better as an even-aged than as a selection forest. The representation of trees in the smaller size classes might be much more even aged than that of the trees in the larger size classes which were removed and which gave it originally the characteristics of a selection forest. This is likely to be the case in stands which have been heavily pastured for a long period of years. In such cases the form of management should be changed from the "selection" system described above to the "shelter-wood" system.

*Even-aged stands.*—In even-aged stands, whether occurring naturally or produced by the management of uneven-aged stands as suggested above, the shelter-wood system may be used with a rotation of 70 to 100 years. The *shelter-wood system* somewhat resembles the system of successive cuttings, already described for other plots, except that the interval between cuttings is longer, natural reproduction instead of planting is depended upon to secure a new stand, and care is taken to maintain as nearly as possible a crown cover of uniform density over the whole area. This system is not likely to be practicable for stands of this kind in the immediate future. The essential principles of its application are to open the stand gradually in order to prevent too sudden exposure of existing young growth and to secure additional reproduction under the shelter of the old stand before it is wholly removed. The possibility of using it depends chiefly upon market conditions and logging costs. When these are most favorable several cuttings are made, but under present American conditions not more than two cuttings are possible.

The first cutting is made about 20 years before the end of the rotation, removing about half of the original number of trees. After reproduction is secured and is well started, the remainder of the original stand is removed in a final cutting.

With the faster growing species, like white ash, basswood, and red oak, a rotation of 70 years may be used, but 100 years are needed for the slower growing hardwoods. Considering the species which must be favored if the object is gipsy-moth control. a rotation of 100 years would be necessary.

*Planting.*—In the northern hardwoods region, of which this stand is typical, the greater part of the woodland must be kept growing hardwoods for many years to come. Where intensive methods are possible, the more poorly stocked areas may be changed from hardwood to coniferous stands.

The desirability of this change from the standpoint of gipsy-moth control will depend in each case upon the composition of the actual stand under consideration.

The change can be made best by planting, which it is believed has already been sufficiently considered in the discussion of other stands.

In view of its freedom from attack by the white-pine blister rust it is desired to emphasize the increased importance of red, or Norway pine for planting in the region infested with the gipsy moth.

## CONCLUSIONS.

No single rule or simple formula can be given by which to secure in woodlands the control of the gipsy moth by forest management. Each lot and each combination of species presents a problem in which the controlling factors are site, soil, location, market, species present, their value and relative proportion, the degree of infestation, and the cost of labor.

In many cases these factors combine in such a way that management is economically impossible.

It is believed that the suggestions contained herein have been made so definite that a careful reading will enable any owner or other person interested in the problem to discriminate between results which may and those which may not reasonably be expected under certain conditions, which have been selected because typical of those on large areas within the infested region.

While we are waiting for definite results from the various experiments now in progress, some of which have been referred to in the preceding pages, it is well for foresters and entomologists squarely to face the fact that the possible field of forest management as a method of controlling the gipsy moth is strictly limited.

Even in the mixed hardwoods type, where success may in some cases reasonably be expected, the cost will often be prohibitive.

In other forest types, and in the other forest regions within the area now infested by the gipsy moth, general control by forest management may or may not prove to be an economic possibility.

Throughout the infested region much may be expected from outbreaks of the wilt disease and the gradual subsidence of the gipsy moth to a normal place among other injurious insects.

To control the moth in many of the stands of the mixed-hardwoods type of the white-pine region, spraying and creosoting must be used, while birds, parasites, and insect enemies must do their part.

In severe infestations forest management may be less expensive than spraying and creosoting and has the advantage of being constructive instead of merely palliative, but it can not be recommended as a method of relief for general indiscriminate application by States, cities, towns, and private owners of woodlands throughout the infested region.

# APPENDIX.

## SPECIES WHICH ARE NOT CONTROLLING TREES IN THE WHITE-PINE REGION.

### CLASS I.—*Favored food of gipsy-moth larvæ in all stages.*

Ash, Mountain.[1, 2]
Balm of Gilead.[1]
Basswood.[1]
Birch, Paper.[3]
Birch, River.[1, 2]
Boxelder.[1, 2]
Oak, Bur.[1]
Oak, Chestnut.[1]
Oak, Pin.[1]
Oak, Post.[1]
Oak, Swamp white.[1]
Service Berry.[2, 4]
Sumac, Dwarf.[2, 4]
Sumac, Staghorn.[2, 4]
Tamarack.[1]
Willow, Glaucous.[1, 2]
Witch Hazel.[1, 2]

### CLASS II.—*Favored food after earlier stages.*

Pine, Red.[3]
Spruce, Black.[1]
Spruce, Red.[1]
Spruce, White.[1]

### CLASS III.—*Not particularly favored food.*

Birch, Black.[1]
Birch, Yellow.[1]
Beech, Blue.[2, 4]
Cherry, Black.[1]
Cherry, Choke.[2, 4]
Cherry, Wild Red.[2, 4]

### CLASS III.—*Not particularly favored food*—Continued.

Cottonwood.[1]
Elm, American.[3]
Elm, Slippery.[1]
Gum, Black.[3]
Hickory, Bitternut.[1]
Hickory, Mockernut.[1]
Hickory, Pignut.[3]
Hickory, Shagbark.[3]
Hop Hornbeam.[2, 4]
Maple, Silver.[1]
Poplar, Silver.[1]
Sassafras.[1, 2]

### CLASS IV.—*Unfavored food.*

Arborvitæ.[1]
Ash, Black.[3]
Ash, Red.[1]
Balsam Fir.[3]
Butternut.[1]
Dogwood, Flowering.[2, 4]
Hackberry.[1]
Holly, American.[4]
Laurel, Mountain.[2, 4]
Locust, Black.[1]
Locust, Honey.[1]
Maple, Mountain.[2, 4]
Maple, Striped.[2, 4]
Mulberry, Red.[1]
Sheepberry.[2, 4]
Sycamore.[1]
Tulip.[1]
Walnut, Black.[1]

## PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE ON THE GIPSY MOTH.

### 1. FARMERS' BULLETINS.

No.

275. The Gipsy Moth and How to Control It. L. O. Howard, 1907. 22 pages, illus. (Superseded by No. 564.)

453. Danger of General Spread of the Gipsy and Brown-tail Moths through Imported Nursery Stock. C. L. Marlatt, 1911. 22 pages, illus.

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[1] Occurs infrequently.

[2] Of low value.

[3] A few stands in the region may be found where this species is sufficiently represented to require consideration in making plans of management.

[4] Always small in this region.

No.

564. The Gipsy Moth and the Brown-tail Moth, with Suggestions for Their Control. A. F. Burgess, 1914. 24 pages, illus.

### 2. BUREAU OF ENTOMOLOGY CIRCULARS.

58.[1] Report on the Gipsy Moth and the Brown-tail Moth, July 1904. C. L. Marlatt. 12 pages, 2 maps.

164. The Gipsy Moth as a Forest Insect, with Suggestions as to Its Control. W. F. Fiske, 1913. 20 pages.

### 3. BUREAU OF ENTOMOLOGY BULLETINS. NEW SERIES.

11. Gipsy Moth in America. Account of Introduction and Spread of *Porthetria dispar* in Massachusetts and of Efforts Made by the State to Repress and Exterminate It. L. O. Howard, 1897. 39 pages, illus., maps.

67.[1] Proceedings 19th Annual Meeting Association of Economic Entomologists, 1907. Pages 22–26. Occurrence of the Gipsy Moth in Connecticut. W. E. Britton.

87. Report on Field Work against Gipsy Moth. D. M. Rogers and A. F. Burgess, 1910. 81 pages, illus., map.

91. Importation into the United States of Parasites of the Gipsy Moth and the Brown-tail Moth. L. O. Howard and W. F. Fiske, 1911. 344 pages, illus., maps.

101. Calosoma sycophanta: Its Life History, Behavior, and Successful Colonization in New England. A. F. Burgess, 1911. 94 pages, illus., map.

119. The Dispersion of the Gipsy Moth. A. F. Burgess, 1913. 62 pages, illus., map.

### 4. DEPARTMENT BULLETINS.

204. Report on the Gipsy Moth Work in New England. A. F. Burgess, 1915. 32 pages, illus., maps.

250. Food Plants of the Gipsy Moth in America. F. H. Mosher, 1915. 39 pages, illus.

251. The Calosoma Beetle (*Calosoma sycophanta*) in New England. A. F. Burgess and C. W. Collins, 1915. 40 pages, illus., map.

273. Dispersion of Gipsy Moth Larvæ by the Wind. C. W. Collins, 1915. 23 pages, illus., maps.

### 5. OTHER DEPARTMENTAL PUBLICATIONS.

Gipsy and Brown-tail Moths and their European Parasites. L. O. Howard. Yearbook of the Department of Agriculture for 1905. Pages 123 to 138, illus.

Wilt of Gipsy Moth Caterpillars. R. W. Glaser. Jour. of Agr. Research, 1915, Vol. IV, No. 2, pages 101 to 128, illus.

### 6. BUREAU OF ENTOMOLOGY BULLETINS, TECHNICAL SERIES.

12. Part VI.[1] A Record of Results from Rearings and Dissections of Tachinidæ. Charles H. T. Townsend, 1908. 24 pages, illus.

19. Technical Results from the Gipsy Moth Parasite Laboratory.

    Part I. The Parasites Reared or Supposed to have been Reared from the Eggs of the Gipsy Moth. L. O. Howard, 1910. Pages 1 to 12, illus.

    Part II.[1] Descriptions of Certain Chalcidoid Parasites. J. C. Crawford, 1910. Pages 13 to 24, illus.

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No.

19. Technical Results from the Gipsy Moth Parasite Laboratory—Continued.
    Part III.[1] Investigations into the Habits of Certain Sarcophagidæ. T. L. Patterson. Introduction by W. F. Fiske, 1911. Pages 25 to 32.
    Part IV.[1] The Chalcidoid genus *Perilampus*, and its Relations to the Problem of Parasite Introduction. Harry S. Smith, 1912. Pages 33 to 70, illus.
    Part V.[1] Experimental Parasitism. A Study of the Biology of *Limnerium validum* (Cresson). P. H. Timberlake, 1912. Pages 71 to 92, illus.

## PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE ON CONTROLLING TREES.

### FOREST SERVICE BULLETINS.

No.

31. Notes on the Red Cedar. Charles Mohr, 1901. 37 pages, illus.
42. The Woodlot: Handbook for Owners of Woodlands in Southern New England. H. S. Graves and R. T. Fisher, 1903. 89 pages, illus.
53. Chestnut in Southern Maryland. Raphael Zon, 1904. 31 pages, illus.
63. Natural Replacement of White Pine on Old Fields in New England. S. N. Spring, 1905. 32 pages, illus., map.
93. The Aspens: Their Growth and Management. W. G. Weigle and E. H. Frothingham, 1911. 35 pages.
95. Uses of Commercial Woods of the U. S. I. Cedars (White Cedar, pp. 12–16) (Red Cedar, pp. 19–29). Wm. L. Hall and H. Maxwell, 1911. 62 pages.
96. Second Growth Hardwoods in Connecticut. E. H. Frothingham, 1912. 70 pages, illus.
99. Uses of Commercial Woods of the U. S. II. Pines (Pitch Pine, pp. 31–34) (White Pine, pp. 35–54). Wm. L. Hall and H. Maxwell, 1911. 96 pages.

### DEPARTMENT BULLETINS.

12. Uses of Commercial Woods of the U. S. Beech, Birches, and Maples. H. Maxwell, 1913. 56 pages.
152. The Eastern Hemlock (*Tsuga canadensis*). E. H. Frothingham, 1915. 43 pages, illus., map.
299. The Ashes: Their Characteristics and Management. W. D. Sterrett, 1915. 88 pages, illus., map.

## PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE ON TREE PLANTING.

### FOREST SERVICE BULLETINS.

29.[1] The Forest Nursery. Geo. B. Sudworth, 1900. 63 pages, illus.
45. The Planting of White Pine in New England. Harold B. Kempton, 1903. 40 pages, illus.
76. How to Grow and Plant Conifers in Northeastern States. C. R. Pettis, 1909. 36 pages, illus.

### DEPARTMENT BULLETINS.

13. White Pine under Forest Management. E. H. Frothingham, 1914. 70 pages.
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## FOREST SERVICE CIRCULARS.

No.

58. Forest Planting Leaflet. Red Oak (*Quercus rubra*), 1911. 4 pages.

60.[1] Forest Planting Leaflet. Red Pine (*Pinus resinosa*), 1907. 4 pages.

61. Forest Planting Leaflet. How to transplant forest trees, 1911. 4 pages.

67.[1] Forest Planting Leaflet. White Pine (*Pinus strobus*), 1907. 6 pages.

69. Forest Planting Leaflet. Fence post trees, 1907, 4 pages.

71.[1] Forest Planting Leaflet. Chestnut (*Castanea dentata*), 1907. 4 pages.

73. Forest Planting Leaflet. Red Cedar (*Juniperus virginiana*), 1907. 4 pages.

84. Forest Planting Leaflet. White Ash (*Fraxinus americana*), 1907. 4 pages.

93. Forest Planting Leaflet. Yellow Poplar or Tulip tree (*Liriodendron tulipifera*), 1907. 4 pages.

95. Forest Planting Leaflet. Sugar Maple (*Acer saccharum*), 1907. 4 pages.

106.[1] Forest Planting Leaflet. White Oak (*Quercus alba*), 1907. 4 pages.

195. Forest Planting in the Northeastern and Lake States, 1912. 15 pages, illus.

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Joint Contribution from the Bureau of Plant Industry, WM. A. TAYLOR, Chief
and the Bureau of Crop Estimates, L. M. ESTABROOK, Chief

Washington, D. C. ▼ January 20, 1917

# APPLES: PRODUCTION ESTIMATES AND IMPORTANT COMMERCIAL DISTRICTS AND VARIETIES

By

H. P. GOULD, Bureau of Plant Industry, and
FRANK ANDREWS, Bureau of Crop Estimates

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Washington, D. C. ▼ January 20, 1917

# APPLES: PRODUCTION ESTIMATES AND IMPORTANT COMMERCIAL DISTRICTS AND VARIETIES.

By H. P. Gould, *Bureau of Plant Industry*, and Frank Andrews, *Bureau of Crop Estimates*.

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## STATISTICAL ESTIMATES OF VARIETIES.

From a study made in 1910 of nursery catalogues issued for that year it appeared that the nurserymen of the United States were then offering to the trade trees of at least 500 different varieties of apples. It is to be assumed there was some demand for most of the varieties catalogued, otherwise there would have been no inducement to propagate them. The number of varieties offered for sale at the present time is doubtless somewhat less than it was in 1910, as there is a tendency to decrease rather than to increase it, but the decrease is not very rapid.

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Note.—This bulletin is of general interest to those concerned with the apple industry. The information which it contains in regard to the areas where apples are grown extensively and the principal varieties produced in them is based largely on reports received from correspondents who were requested to supply such information and who were addressed in this connection because of their familiarity with the fruit interests in the States in which they live. All diagrams and figures showing estimates, except as noted, have been contributed by the Bureau of Crop Estimates.

However, the number of varieties that are produced in large quantities is relatively small. This is shown in figure 1, where each bar represents the estimated average relative proportion of the variety indicated in the crops for 1909 to 1913, inclusive. The proportions are shown also in Table I in barrels and percentages. The total yield is based on the report of the Thirteenth Census (for 1909) and upon the reports of crop correspondents of the Bureau of Crop Estimates.

TABLE I.—*Estimated average production of 35 of the most important varieties of apples, showing the percentage relation of each variety to the entire crop, for the years 1909 to 1913, inclusive.*

| Variety. | Production. | Relation to total crop. |
|---|---|---|
| | *Barrels.* | *Per ct.* |
| White Pearmain (*White Winter Pearmain*) | 269,000 | 0.5 |
| Arkansas (*Mammoth Black Twig*) | 393,000 | .7 |
| Missouri (*Missouri Pippin*) | 499,000 | .8 |
| Wolf River | 503,000 | .9 |
| Arkansas Black | 526,000 | .9 |
| McIntosh (*McIntosh Red*) | 530,000 | .9 |
| Horse (*Yellow Horse*) | 545,000 | .9 |
| Northwestern | 553,000 | .9 |
| Tolman (*Talman Sweet*) | 592,000 | 1.0 |
| Gravenstein | 619,000 | 1.1 |
| Fameuse (*Snow*) | 775,000 | 1.3 |
| Tompkins King (*King of Tompkins County*) | 797,000 | 1.4 |
| Golden Russet | 830,000 | 1.4 |
| Yellow Bellflower | 845,000 | 1.4 |
| Yellow Transparent | 893,000 | 1.5 |
| Stayman Winesap | 907,000 | 1.5 |
| Red June (*Carolina Red June*) | 914,000 | 1.6 |
| Limbertwig (*Red Limbertwig*) | 915,000 | 1.6 |
| Gano | 927,000 | 1.6 |
| Yellow Newtown (*Albemarle; Newtown Pippin*) | 968,000 | 1.6 |
| Fall Pippin | 988,000 | 1.7 |
| Oldenburg (*Duchess of Oldenburg*) | 1,097,000 | 1.9 |
| Red Astrachan | 1,120,000 | 1.9 |
| Maiden Blush | 1,203,000 | 2.0 |
| York Imperial (*Johnson Fine Winter*) | 1,262,000 | 2.1 |
| Grimes (*Grimes Golden*) | 1,294,000 | 2.2 |
| Wealthy | 1,322,000 | 2.2 |
| Early Harvest (*Prince's Harvest*) | 1,641,000 | 2.8 |
| Rome Beauty | 1,813,000 | 3.1 |
| Jonathan | 2,135,000 | 3.6 |
| Rhode Island Greening (*Greening*) | 2,767,000 | 4.7 |
| Winesap | 3,012,000 | 5.1 |
| Northern Spy | 3,570,000 | 6.1 |
| Ben Davis | 7,833,000 | 13.3 |
| Baldwin | 7,861,000 | 13.4 |
| Other varieties | 6,109,000 | 10.4 |
| Total | 58,827,000 | 100 |

It is to be observed that there are but 35 varieties named in figure 1 and Table I, or only about 7 per cent of the number which doubtless were being planted more or less in different parts of the country during the period covered by these records. These 35 varieties include all those which constituted, as estimated, one-half of 1 per cent (0.5 per cent) or more of the entire crop of the country.

It will be noted also that these 35 varieties constituted nearly 90 per cent of the entire crop, while "other varieties," that is, those not mentioned by name and which doubtless numbered several hundred,[1] comprised but little more than 10 per cent of the whole crop.

The relative number of these varieties which are now prominent is destined to change materially within the next few years. Certain ones in the list, such as Missouri and Limbertwig, have been

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[1] This number can not well be determined even approximately, as it doubtless includes varieties growing in the older orchards which are not now propagated by nurserymen.

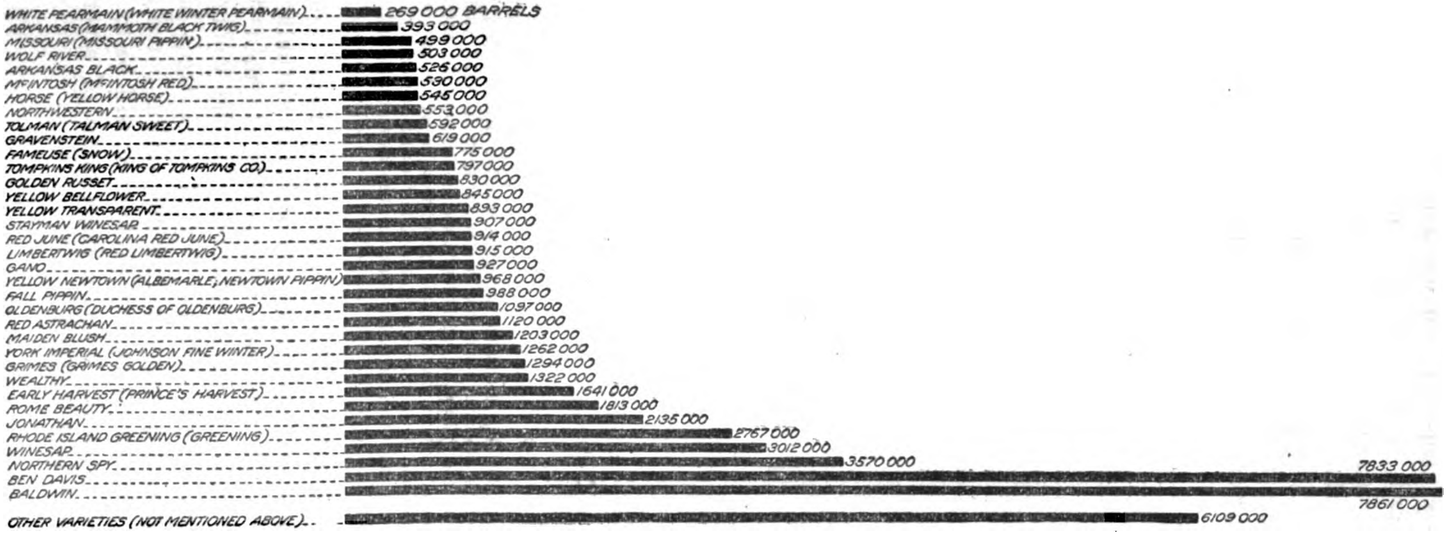

FIG. 1.—Diagram showing the estimated average crop of different apple varieties and the relative proportion of each variety to the entire crop in the United States, for 1909 to 1918, inclusive.

planted but very little in recent years, though they are in many of the older orchards at the present time. The same thing is true in a measure of Ben Davis, which in 1915 comprised a larger proportion of the crop than any other single variety, as shown in the estimates in Table II. It has not been planted so much during the past 5 or 10 years (either relatively or actually) as in former years, and in some sections where planted heavily at an earlier period it has proved unprofitable. The trees therefore have been dug up or worked over to other varieties, or the orchards virtually abandoned.

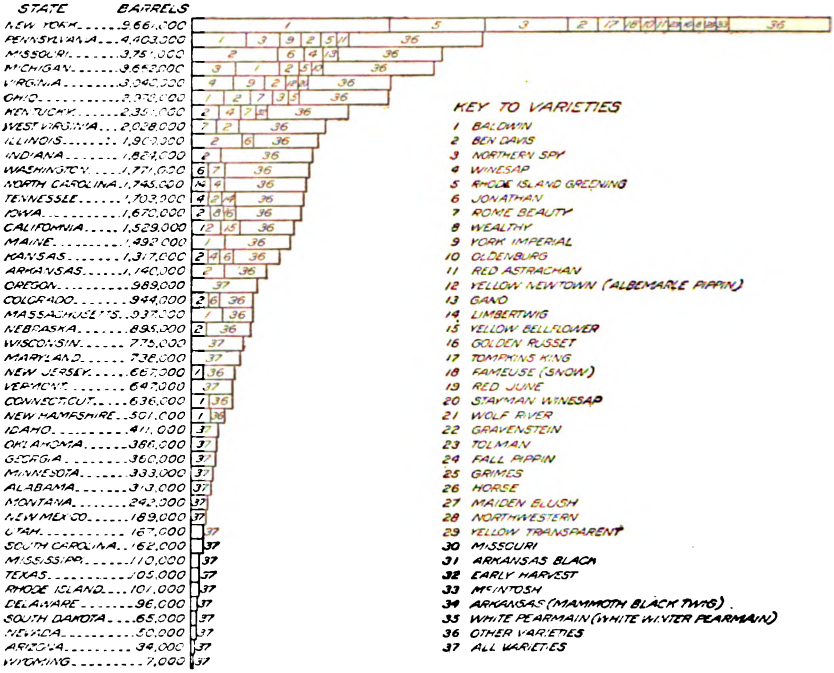

FIG. 2.—Diagram showing the estimated average relative proportion of different apple varieties in the crops of each State for the years 1909 to 1913, inclusive. Several varieties named in the "Key to varieties" are not separately referred to in the diagram. Because of the relatively small quantities in which the omitted varieties are produced in any one State they are included in "Other varieties." These varieties are given in the key, however, in order that the list may include all that are shown in figure 1 and Tables I and III.

On the other hand, some varieties, notably Stayman Winesap and McIntosh, have been planted extensively in the younger orchards in some sections. Comparatively few of these trees have reached full bearing age as yet, many in fact not having borne at all. The result of these changes in variety preference will be to modify materially in the future the relative importance of several varieties named in figure 1 and Table I.

The estimated production of the 22 principal sorts that comprised the crop of 1915 and the relation of each to the entire crop for that year are shown in Table II.

TABLE II.—*Estimated production of the 22 most important varieties of apples, showing the percentage relation of each to the entire crop, for the year 1915.*[1]

| Variety. | Production. | | Variety. | Production. | |
|---|---|---|---|---|---|
| | Relation to total crop. | Thousand barrels.[2] | | Relation to total crop. | Thousand barrels.[2] |
| | *Per cent.* | | | *Per cent.* | |
| Ben Davis | 14.5 | 11,100 | Limbertwig | 2.0 | 1,511 |
| Baldwin | 10.9 | 8,312 | Yellow Newtown | 1.7 | 1,324 |
| Winesap | 7.3 | 5,545 | Fameuse | 1.3 | 996 |
| Jonathan | 5.9 | 4,489 | Tompkins King | 1.3 | 975 |
| Rhode Island Greening | 4.7 | 3,595 | Yellow Bellflower | 1.2 | 939 |
| Rome Beauty | 4.6 | 3,524 | Golden Russet | 1.2 | 879 |
| Wealthy | 4.3 | 3,296 | Wagener | 1.1 | 822 |
| Grimes | 3.8 | 2,913 | McIntosh | 1.0 | 773 |
| Northern Spy | 3.8 | 2,878 | Gravenstein | .9 | 669 |
| York Imperial | 3.2 | 2,456 | Others | 17.7 | 13,547 |
| Oldenburg | 2.9 | 2,185 | | | |
| Gano | 2.4 | 1,852 | Total | 100 | 76,350 |
| Stayman Winesap | 2.3 | 1,770 | | | |

[1] Monthly Crop Reporter, Apr. 15, 1916, p. 35. The yield is based on the estimates reported in the Thirteenth Census (for 1909) and upon annual reports of crop correspondents of the Bureau of Crop Estimates. About 18 per cent of the crop was classed as summer apples, 25 per cent fall, and 57 per cent winter apples.

[2] The totals do not include 320,000 barrels grown in Rhode Island, South Carolina, and Nevada, where the data were insufficient.

While figure 1 shows the estimated relative importance of the leading varieties on the basis of the quantity of each produced in the country as a whole, figure 2 gives similar information on a State basis and shows the estimated relative importance in quantity produced of the principal varieties in the different States. This figure is also useful as indicating in a general way the geographical distribution of the more important sorts.

The percentages of the different varieties shown in figure 2 are given in Table III and in the supplementary text.[1]

In important apple-producing States not included in Table III the principal varieties and their respective percentages of all apples in a normal crop are:

*Kentucky.*—Ben Davis, 16.8; Winesap, 14; Rome Beauty, 9.6; Early Harvest, 6.4; Maiden Blush, 4.5; Red June, 4.3; Limbertwig, 4.

*Indiana.*—Ben Davis, 22.8; Baldwin, 7.2; Grimes, 6.7; Winesap, 6.7; Maiden Blush, 5.8; Rome Beauty, 4.4; Northern Spy, 4.2.

*North Carolina.*—Limbertwig, 14.3; Winesap, 12.2; Ben Davis, 7.5; Early Harvest, 7.2; Horse, 7.2; Red June, 5.9.

*Tennessee.*—Winesap, 14.1; Ben Davis, 12.2; Limbertwig, 12.1; Early Harvest, 8.4; Horse, 6.3; Red June, 5.4.

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[1] These figures are taken from the Agricultural Outlook, Farmers' Bulletin 641, Nov. 28, 1914, p. 17.

TABLE III.—*Estimated relative production of 35 principal varieties of apples expressed as percentages of a normal crop of all apples.*

| Variety. | United States. | Maine. | New York. | Pennsylvania. | Virginia. | West Virginia. | Ohio. | Michigan. | Illinois. | Missouri. | Arkansas. | Washington. | California. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arkansas | 0.7 | 0.2 | ...... | 0.3 | 3.1 | 0.7 | 0.1 | 0.0 | 0.6 | 1.1 | 2.3 | 0.3 | 0.3 |
| Arkansas Black | .9 | ...... | ...... | .2 | .7 | .8 | .1 | ...... | .9 | 1.5 | 3.0 | 2.3 | 1.0 |
| Baldwin | 13.4 | 34.5 | 31.3 | 17.8 | 2.8 | 5.8 | 15.6 | 17.0 | 2.7 | 1.5 | .4 | 7.8 | 2.3 |
| Ben Davis | 13.3 | 9.8 | 5.0 | 6.0 | 11.4 | 15.7 | 13.9 | 8.5 | 37.8 | 34.2 | 44.1 | 7.4 | 2.9 |
| Early Harvest | 2.8 | .9 | .9 | 3.1 | 4.7 | 3.9 | 3.7 | 1.8 | 2.2 | 2.8 | 2.0 | .8 | .7 |
| Fall Pippin | 1.7 | .7 | 1.7 | 3.1 | 1.8 | 1.5 | 1.8 | 1.6 | 1.1 | .4 | .7 | .8 | .6 |
| Fameuse | 1.3 | 3.5 | 2.4 | .6 | .1 | .0 | .6 | 3.0 | 1.5 | .4 | .1 | .3 | .0 |
| Gano | 1.6 | .3 | .2 | .8 | .6 | 1.6 | 1.3 | .3 | 3.8 | 6.5 | 6.6 | .8 | .2 |
| Golden Russet | 1.4 | 1.7 | 2.0 | 2.5 | .3 | 1.6 | .9 | 3.7 | .7 | .3 | .1 | .3 | .1 |
| Gravenstein | 1.1 | 2.3 | .9 | 1.0 | .1 | .1 | .3 | .1 | .1 | .1 | ...... | 4.1 | 8.9 |
| Grimes | 2.2 | .2 | .1 | 2.6 | 2.6 | 4.6 | 5.0 | 1.2 | 4.9 | 3.6 | 2.1 | 1.6 | .1 |
| Horse | .9 | ...... | ...... | ...... | 1.0 | .0 | .0 | .0 | .2 | .5 | 1.5 | ...... | ...... |
| Jonathan | 3.6 | .8 | .4 | 1.4 | 1.0 | 1.7 | 1.8 | 2.2 | 9.3 | 10.4 | 3.7 | 13.8 | 1.7 |
| Limbertwig | 1.6 | .0 | .0 | ...... | 2.5 | .8 | .3 | .0 | .6 | 1.5 | 5.8 | ...... | .3 |
| McIntosh | .9 | 3.7 | 1.6 | .7 | .1 | .1 | .1 | .3 | .4 | .1 | ...... | .3 | .1 |
| Maiden Blush | 2.0 | .3 | 1.0 | 3.0 | 1.5 | 2.5 | 4.5 | 2.6 | 2.3 | 2.8 | 1.0 | .3 | .4 |
| Missouri | .8 | .0 | .0 | .0 | .2 | .1 | .1 | .1 | 1.2 | 3.0 | 1.4 | .5 | .9 |
| Northern Spy | 6.1 | 7.1 | 13.1 | 11.4 | .8 | 4.2 | 7.7 | 17.9 | 1.4 | 1.1 | .5 | 3.8 | .6 |
| Northwestern | .9 | .3 | .9 | .4 | .0 | .4 | .6 | 1.9 | .3 | .3 | ...... | 1.0 | .2 |
| Oldenburg | 1.9 | 2.9 | 2.2 | 1.1 | .1 | .5 | 1.0 | 5.0 | 1.7 | .5 | ...... | 1.1 | .1 |
| Red Astrachan | 1.9 | 3.9 | 2.1 | 3.5 | .8 | 2.1 | 2.7 | 2.8 | .8 | .8 | .5 | 1.7 | 3.3 |
| Red June | 1.6 | ...... | .7 | .3 | 1.8 | 1.3 | .2 | .0 | 1.2 | 1.9 | 2.7 | 1.3 | 1.4 |
| Rhode Island Greening | 4.7 | 4.1 | 14.8 | 5.5 | .3 | 1.4 | 5.7 | 5.4 | .8 | .8 | .6 | 2.2 | 2.7 |
| Rome Beauty | 3.1 | .1 | .3 | 2.1 | 1.2 | 18.7 | 10.8 | .2 | 3.8 | 1.7 | 1.8 | 12.2 | 2.4 |
| Stayman Winesap | 1.5 | .6 | .1 | 1.8 | 5.3 | 1.9 | 1.3 | .1 | .5 | 1.8 | 1.7 | 2.7 | .9 |
| Tolman | 1.0 | 2.6 | 2.1 | 1.1 | .1 | .4 | .5 | 2.4 | .3 | .2 | ...... | .9 | .0 |
| Tompkins King | 1.4 | 2.4 | 4.1 | 1.5 | .0 | .5 | .6 | 2.1 | .1 | .1 | ...... | 2.7 | 1.1 |
| Wealthy | 2.2 | 5.4 | 1.8 | 1.2 | .0 | 1.1 | 1.2 | 3.7 | 1.6 | 1.3 | .1 | 1.5 | .1 |
| White Pearmain | .5 | ...... | .1 | .0 | .2 | .2 | .1 | .0 | .2 | .3 | .1 | .6 | 7.5 |
| Winesap | 5.1 | .5 | .1 | 1.8 | 20.7 | 1.8 | 1.8 | .4 | 5.6 | 6.8 | 8.4 | 7.1 | 1.4 |
| Wolf River | .9 | 1.4 | .3 | .3 | .2 | .6 | .5 | 1.5 | .4 | .7 | ...... | .8 | .1 |
| Yellow Bellflower | 1.4 | 1.7 | .3 | 2.3 | .2 | 1.5 | 1.3 | 1.2 | .5 | 1.0 | .1 | 1.9 | 18.6 |
| Yellow Newtown | 1.6 | .0 | .2 | .6 | 7.0 | .3 | .4 | .3 | .2 | .1 | ...... | 2.9 | 28.7 |
| Yellow Transparent | 1.5 | 1.1 | .3 | 1.7 | 1.5 | 3.2 | 2.1 | 1.4 | 2.1 | 1.1 | .4 | 1.5 | .2 |
| York Imperial | 2.1 | ...... | .1 | 7.5 | 15.1 | 5.0 | 1.3 | .3 | .8 | 1.1 | .1 | .2 | .1 |
| Other varieties | 10.4 | 7.0 | 8.9 | 12.8 | 10.2 | 13.4 | 10.1 | 11.0 | 7.4 | 8.2 | 8.2 | 12.5 | 8.2 |
| Number of reports | 2,622 | 55 | 82 | 68 | 57 | 62 | 100 | 122 | 78 | 191 | 42 | 58 | 63 |

*Iowa.*—Ben Davis, 15.2; Wealthy, 12.4; Jonathan, 10.3; Oldenburg, 8.9; Grimes, 4.9; Northwestern, 4.3.

*Kansas.*—Ben Davis, 19.4; Winesap, 15.3; Jonathan, 13.8; Missouri, 8.6; Gano, 6; Maiden Blush, 4.3.

*Oregon.*—Baldwin, 12.6; Yellow Newtown, 11.3; Northern Spy, 7.4; Gravenstein, 7.3; Rome Beauty, 5.6; Tompkins King, 5.1; Ben Davis, 4.9; Jonathan, 4.4.

*Colorado.*—Ben Davis, 26.3; Jonathan, 18.3; Gano, 7.8; Rome Beauty, 4.8; Winesap, 4.1.

*Massachusetts.*—Baldwin, 48.4; Rhode Island Greening, 9.3; Gravenstein, 5.7; McIntosh, 5.7; Northern Spy, 5.1.

*Nebraska.*—Ben Davis, 21.3; Winesap, 13.6; Jonathan, 9.4; Wealthy, 6.2; Oldenburg, 5.8; Grimes, 4.8; Missouri, 4.2; Gano, 4.

*Wisconsin.*—Oldenburg, 14.7; Wealthy, 13.7; Northwestern, 11.1; Fameuse, 8; Wolf River, 7.5; Ben Davis, 5.1; Golden Russet, 4.2.

*Maryland.*—Ben Davis, 17; York Imperial, 16.2; Baldwin, 8.8; Winesap, 7.6; Stayman Winesap, 7; Arkansas, 4.4; Early Harvest, 4.2.

*New Jersey.*—Baldwin, 25.2; Ben Davis, 14.5; Rome Beauty, 5; Early Harvest, 4.7; Rhode Island Greening, 4.3; Northern Spy, 4.2.

*Vermont.*—Baldwin, 15.1; Rhode Island Greening, 12.8; Northern Spy, 12; Fameuse, 8.1; McIntosh, 6.1; Ben Davis, 5.6; Yellow Bellflower, 4.2.

*Connecticut.*—Baldwin, 42.2; Rhode Island Greening, 16.9; Golden Russet, 5.2.

*New Hampshire.*—Baldwin, 51.9; Rhode Island Greening, 5.9; Northern Spy, 5.2; McIntosh, 4.4.

*Idaho.*—Jonathan, 21.3; Rome Beauty, 16.6; Ben Davis, 13.1; Gano, 7.8; Winesap, 4.6.

TABLE IV.—*Estimated average annual production of 27 leading varieties of apples, by principal States, 1909 to 1913, inclusive.*[1]

| Variety and State. | Thousand bushels. |
|---|---|
| **Baldwin:** | |
| New York | 9,071 |
| Pennsylvania | 2,351 |
| Michigan | 1,868 |
| Maine | 1,545 |
| Ohio | 1,394 |
| Massachusetts | 1,360 |
| Connecticut | 805 |
| New Hampshire | 780 |
| New Jersey | 504 |
| Other States | 3,905 |
| Total | 23,583 |
| **Ben Davis:** | |
| Missouri | 3,849 |
| Illinois | 2,154 |
| Arkansas | 1,508 |
| New York | 1,449 |
| Indiana | 1,248 |
| Ohio | 1,242 |
| Kentucky | 1,185 |
| Virginia | 1,040 |
| West Virginia | 955 |
| Michigan | 934 |
| Pennsylvania | 793 |
| Kansas | 766 |
| Iowa | 761 |
| Colorado | 745 |
| Tennessee | 623 |
| Nebraska | 572 |
| Other States | 3,675 |
| Total | 23,499 |
| **Northern Spy:** | |
| New York | 3,797 |
| Michigan | 1,966 |
| Pennsylvania | 1,506 |
| Ohio | 688 |
| Other States | 2,754 |
| Total | 10,711 |
| **Winesap:** | |
| Virginia | 1,888 |
| Kentucky | 988 |
| Missouri | 765 |
| Tennessee | 720 |
| North Carolina | 639 |
| Kansas | 605 |
| Other States | 3,431 |
| Total | 9,036 |
| **Rhode Island Greening:** | |
| New York | 4,289 |
| Pennsylvania | 727 |
| Michigan | 593 |
| **Rhode Island Greening—Continued.** | |
| Ohio | 509 |
| Other States | 2,182 |
| Total | 8,300 |
| **Jonathan:** | |
| Missouri | 1,170 |
| Washington | 733 |
| Kansas | 545 |
| Illinois | 530 |
| Colorado | 518 |
| Iowa | 516 |
| Other States | 2,393 |
| Total | 6,405 |
| **Rome Beauty:** | |
| West Virginia | 1,138 |
| Ohio | 965 |
| Kentucky | 677 |
| Washington | 648 |
| Other States | 2,011 |
| Total | 5,439 |
| **Wealthy:** | |
| Iowa | 621 |
| New York | 522 |
| Other States | 2,824 |
| Total | 3,967 |
| **York Imperial:** | |
| Virginia | 1,377 |
| Pennsylvania | 991 |
| Other States | 1,418 |
| Total | 3,786 |
| **Oldenburg:** | |
| New York | 638 |
| Michigan | 549 |
| Other States | 2,103 |
| Total | 3,290 |
| **Red Astrachan:** | |
| New York | 609 |
| Other States | 2,750 |
| Total | 3,359 |
| **Yellow Newtown:** | |
| California | 1,316 |
| Virginia | 638 |
| Other States | 950 |
| Total | 2,904 |
| **Gano:** | |
| Missouri | 732 |
| Other States | 2,048 |
| Total | 2,780 |
| **Limbertwig:** | |
| North Carolina | 749 |
| Tennessee | 618 |
| Other States | 1,378 |
| Total | 2,745 |
| **Yellow Bellflower:** | |
| California | 853 |
| Other States | 1,683 |
| Total | 2,536 |
| **Golden Russet:** | |
| New York | 580 |
| Other States | 1,909 |
| Total | 2,489 |
| **Tompkins King:** | |
| New York | 1,188 |
| Other States | 1,202 |
| Total | 2,390 |
| **Fameuse:** | |
| New York | 696 |
| Other States | 1,629 |
| Total | 2,325 |
| **Tolman:** | |
| New York | 609 |
| Other States | 1,167 |
| Total | 1,776 |
| **Varieties each of which produces less than 500,000 bushels in any one State:** | |
| Early Harvest | 4,923 |
| Grimes | 3,882 |
| Maiden Blush | 3,610 |
| Fall Pippin | 2,963 |
| Red June | 2,743 |
| Stayman Winesap | 2,720 |
| Yellow Transparent | 2,679 |
| Gravenstein | 1,857 |
| All others | 29,776 |
| Total, all varieties | 176,473 |

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[1] The Agricultural Outlook, Farmers' Bulletin 641, Nov. 23, 1914, p. 19.

*Oklahoma.*—Ben Davis, 25.8; Missouri, 12.1; Jonathan, 8.2; Winesap, 8.1; Arkansas Black, 5.6; Gano, 4.

*Georgia.*—Horse, 14.3; Ben Davis, 12.2; Red June, 10; Limbertwig, 8.8; Winesap, 7.6; Early Harvest, 6.1; Arkansas Black, 4.6.

For 27 of the principal varieties the estimated average number of bushels is shown in Table IV. The principal States of production are also shown where the crop in any one State amounts to at least 500,000 bushels.

The distribution by States of the Baldwin, Ben Davis, Northern Spy, Winesap, and Rhode Island Greening—the five varieties produced in the largest quantities—is visualized in the accompanying outline maps (figs. 3 to 7). It is to be noted that each dot on the maps represents an estimated annual average crop of 100,000 bushels. In the States, therefore, in which less than that quantity of any one of these varieties is reported no dots are shown on the maps.

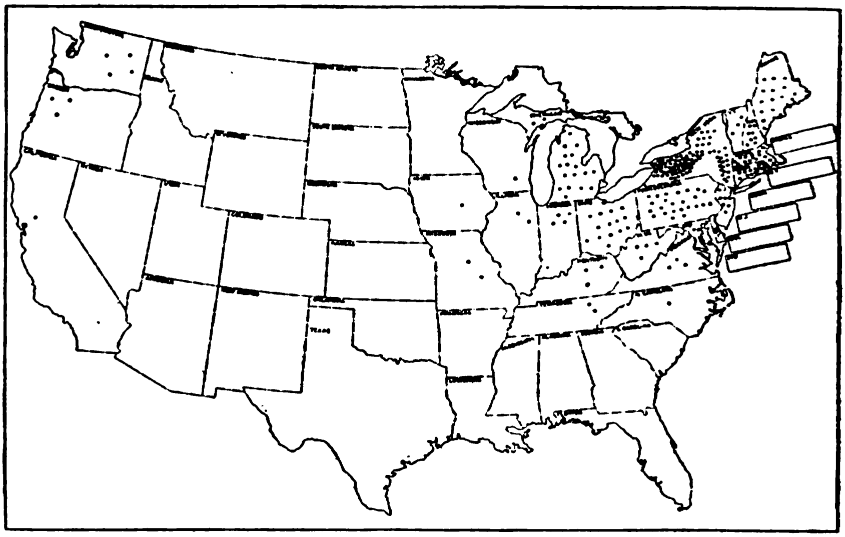


FIG. 3.—Outline map of the United States, showing the distribution by States of the Baldwin apple, each dot representing 100,000 bushels, the total being the estimated average crop for 1909 to 1913, inclusive. The arrangement of the dots within the State boundaries has no significance.

## IMPORTANT CENTERS OR AREAS OF APPLE PRODUCTION.

The statistical consideration of apple varieties given on the preceding pages presents the best available data regarding the estimated quantity of applies produced in the United States in an average year, and the relative importance of the more prominent varieties. The figures are based on census reports and have to do with the entire crop without distinction between the part grown for commercial purposes and that produced in home or farm orchards. A more detailed survey of the distribution of the apple industry from the production standpoint follows. In this discussion emphasis is placed on the centers or areas of commercial apple growing, but the general distribution of this fruit is also indicated.

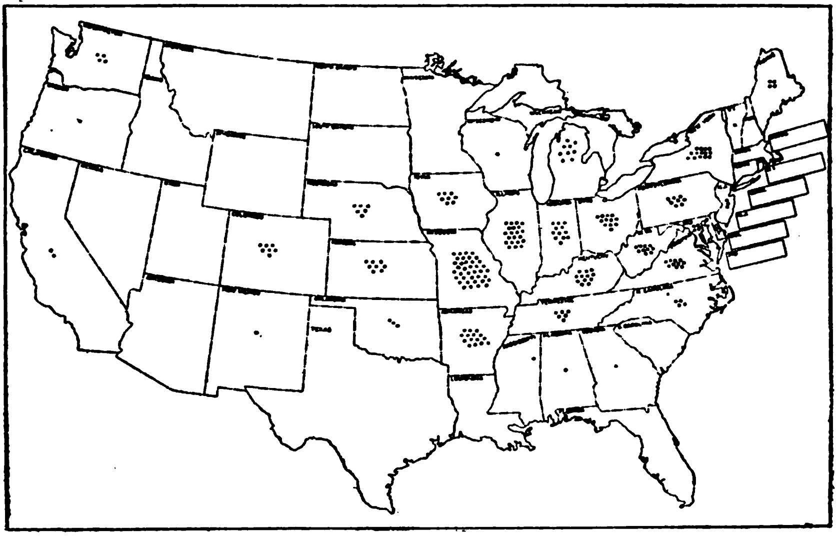


FIG. 4.—Outline map of the United States, showing the distribution by States of the Ben Davis apple, each dot representing 100,000 bushels, the total being the estimated average crop for 1909 to 1913, inclusive. The arrangement of the dots within the State boundaries has no significance.

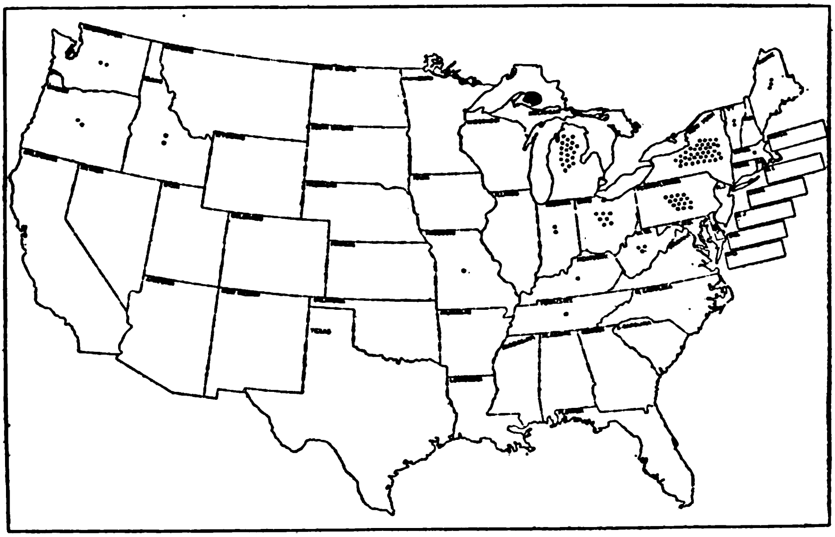


FIG. 5.—Outline map of the United States, showing the distribution by States of the Northern Spy apple, each dot representing 100,000 bushels, the total being the estimated average crop for 1909 to 1913, inclusive. The arrangement of the dots within the State boundaries has no significance.

With the exception of relatively small areas located in the South Atlantic and Gulf coast regions where it is too warm, in the upper Mississippi Valley where it is too cold, and in some sections of the semiarid regions and in the intermountain States where it is either too cold or too dry, or both, there is hardly a community where

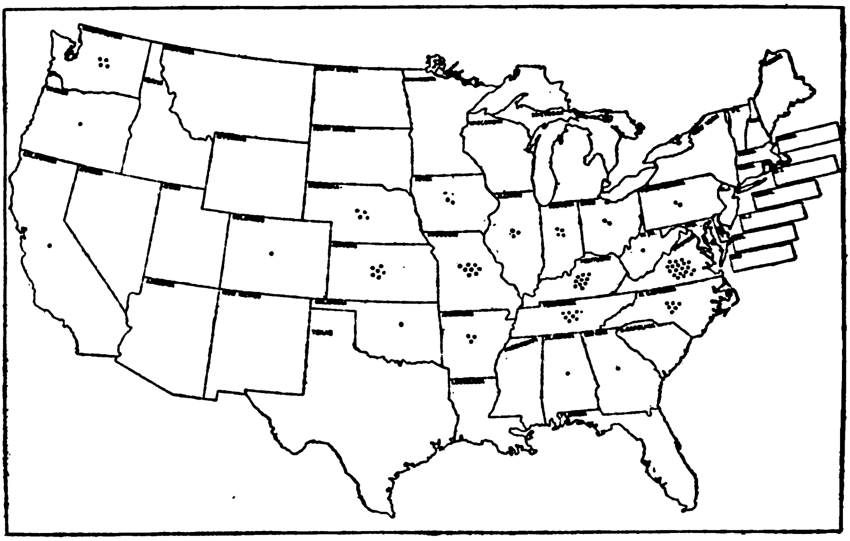


FIG. 6.—Outline map of the United States, showing the distribution by States of the Winesap apple, each dot representing 100,000 bushels, the total being the estimated average crop for 1909 to 1913, inclusive. The arrangement of the dots within the State boundaries has no significance.

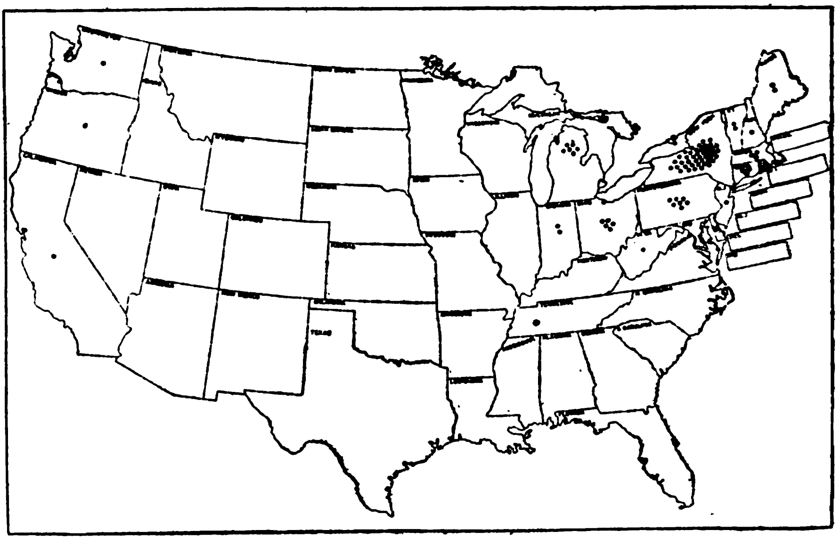
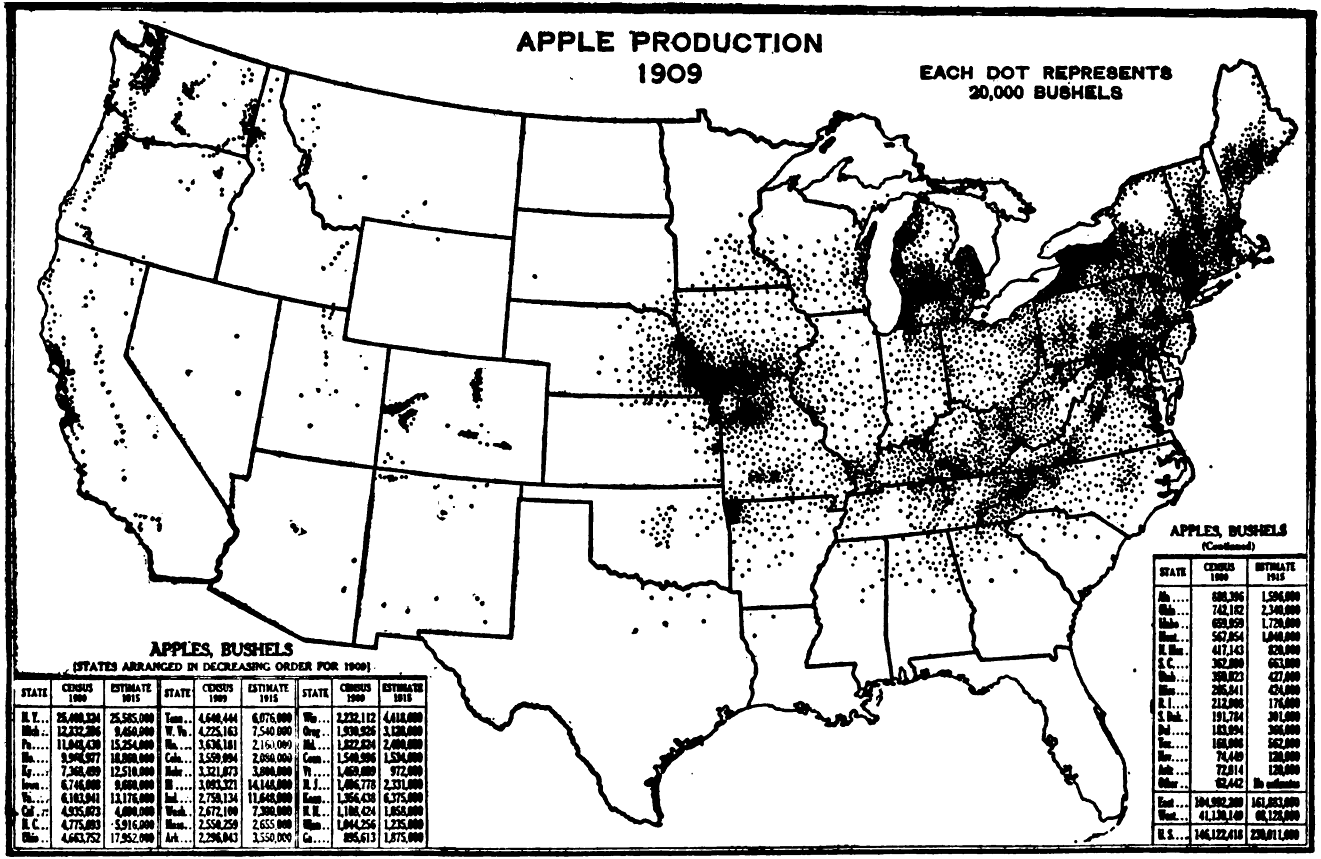


FIG. 7.—Outline map of the United States, showing the distribution by States of the Rhode Island Greening apple, each dot representing 100,000 bushels, the total being the estimated average crop for 1909 to 1913, inclusive. The arrangement of the dots within the State boundaries has no significance.



APPLES, BUSHELS

(STATES ARRANGED IN DECREASING ORDER FOR 1909)

| STATE | CENSUS 1909 | ESTIMATE 1915 | STATE | CENSUS 1909 | ESTIMATE 1915 | STATE | CENSUS 1909 | ESTIMATE 1915 |
|---|---|---|---|---|---|---|---|---|
| N. Y. . . | 25,409,324 | 25,585,000 | Tenn. . | 4,640,444 | 6,076,000 | Wis. . . | 2,232,112 | 4,418,000 |
| Mich. . | 12,332,296 | 9,450,000 | W. Va. . | 4,225,163 | 7,540,000 | Oreg. . | 1,930,926 | 3,120,000 |
| Pa. . . . | 11,048,430 | 15,254,000 | Me. . . . | 3,636,181 | 2,160,000 | Md. . . . | 1,822,824 | 2,400,000 |
| Mo. . . . | 9,948,977 | 18,800,000 | Colo. . . | 3,559,994 | 2,050,000 | Conn. . | 1,540,996 | 1,534,000 |
| Ky. . . . | 7,368,459 | 12,510,000 | Nebr. . | 3,321,073 | 3,800,000 | Vt. . . . | 1,469,089 | 972,000 |
| Iowa . . | 6,746,008 | 9,600,000 | Ill. . . . | 3,080,321 | 14,148,000 | N. J. . . | 1,406,778 | 2,331,000 |
| Va. . . . | 6,183,941 | 13,176,000 | Ind. . . . | 2,758,134 | 11,648,000 | Kans. . | 1,366,438 | 6,375,000 |
| Cal. . . | 4,935,073 | 4,000,000 | Wash. . | 2,672,100 | 7,390,000 | N. H. . . | 1,108,424 | 1,058,000 |
| N. C. . . | 4,775,003 | 5,916,000 | Mass. . | 2,550,250 | 2,655,000 | Minn. . | 1,044,256 | 1,235,000 |
| Ohio . . | 4,663,752 | 17,952,000 | Ark. . . | 2,296,043 | 3,550,000 | Ga. . . . | 895,613 | 1,875,000 |

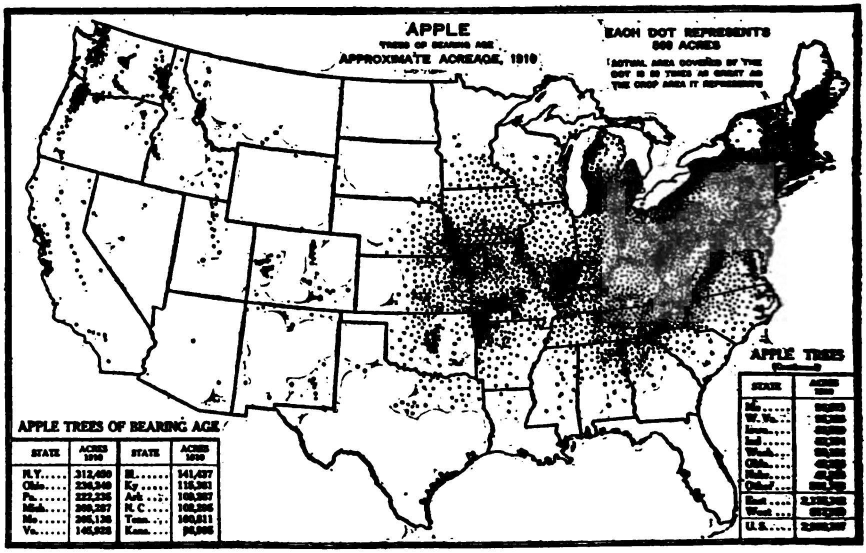
APPLES, BUSHELS

(Continued)

| STATE | CENSUS 1909 | ESTIMATE 1915 |
|---|---|---|
| Ala. . . . | 808,396 | 1,596,000 |
| Okla. . . | 742,182 | 2,340,000 |
| Idaho . . | 658,959 | 1,720,000 |
| Mont. . . | 567,054 | 1,040,000 |
| N. Mex. . | 417,143 | 820,000 |
| S. C. . . . | 362,000 | 653,000 |
| Utah . . . | 350,023 | 427,000 |
| Miss. . . | 285,841 | 424,000 |
| R. I. . . . | 212,908 | 176,000 |
| S. Dak. . | 191,784 | 301,000 |
| Del. . . . | 183,894 | 306,000 |
| Tex. . . . | 168,906 | 562,000 |
| Nev. . . . | 74,449 | 120,000 |
| Ariz. . . | 72,814 | 120,000 |
| Other . . | 62,442 | No estimate |
| East . . . | 104,992,280 | 161,883,000 |
| West . . | 41,130,140 | 68,128,000 |
| U. S. . . | 146,122,418 | 230,011,000 |

FIG. 8.—Outline map of the United States, showing the distribution of apple production in 1909. Each dot represents 20,000 bushels.

apples are not grown to a greater or less extent. The distribution of production based on the reports of the Thirteenth Census is shown in the map designated as figure 8.[1] On this map each dot represents 20,000 bushels on the basis of the crop of 1909, which is the one reported in the last census. The arrangement of the dots on the map is definite and significant, being so placed as to show the geographical distribution of the crop in each State by counties. The heavily shaded areas denote sections of very large production. The clear spaces do not indicate necessarily areas of no apple production, but areas in which the production is so small that no county has a yield amounting to 20,000 bushels.


APPLE
TREES OF BEARING AGE
APPROXIMATE ACREAGE, 1910
EACH DOT REPRESENTS 500 ACRES
(ACTUAL AREA COVERED BY THE DOT IS 50 TIMES AS GREAT AS THE CROP AREA IT REPRESENTS)

APPLE TREES OF BEARING AGE

| STATE | ACRES 1910 | STATE | ACRES 1910 |
|---|---|---|---|
| N.Y. | 312,450 | Ill. | 141,437 |
| Ohio | 236,349 | Ky. | 115,361 |
| Pa. | 222,235 | Ark. | 109,287 |
| Mich. | 209,287 | N.C. | 102,396 |
| Mo. | 205,138 | Tenn. | 100,811 |
| Va. | 145,928 | Kans. | 98,966 |

APPLE TREES (Continued)

| STATE | ACRES 1910 |
|---|---|
| Me. | [illegible] |
| W.Va. | [illegible] |
| Iowa | [illegible] |
| Ind. | [illegible] |
| Wash. | [illegible] |
| Okla. | [illegible] |
| Nebr. | [illegible] |
| Other | [illegible] |
| East | [illegible] |
| West | [illegible] |
| U.S. | [illegible] |

FIG. 9.—Outline map of the United States, showing the approximate distribution of apple orchards of bearing age in 1910. Each dot represents 500 acres.

Figure 9 shows the distribution of apple trees of bearing age, as reported by the Thirteenth Census. In the same way, the distribution of trees of nonbearing age is shown in figure 10. In these two figures each dot represents 500 acres of apple trees. The arrangement of the dots and their positions on the maps have the same significance as those in figure 8.

It is impracticable to present a complete inventory of the apple industry from the standpoint of the distribution of the entire production, but it is believed that an outline of the more important centers and areas of the commercial interests will be of constructive value to all who are concerned with the industry, and at the same time it will supply a type of information the demand for which seems to be increasing.

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[1] This map, also those designated as figures 9 and 10, are from the Yearbook of the Department of Agriculture for 1915.

In indicating where the more important apple-producing sections are located, it is not possible to give the information for the different States with a uniform degree of definiteness, because of the differences in the distribution of the orchards and also because of a lack of sufficient data. In some parts of the country the apple-producing areas are rather indefinite in their extent, with no well-defined boundaries; in others, as in some of the irrigated valleys of the West, the areas are very definitely delimited.

The locations of the more important areas of production, as outlined in the present connection, are indicated largely on the basis of information from leading fruit growers, officers of horticultural societies, experiment station officials, and others who by virtue of their relation to the fruit interests in their respective States are especially familiar with the sources of production. This information was supplied in response to a circular letter sent from the Bureau of Plant Industry. In most cases the varieties listed for planting in the different centers or areas of production were named by the same correspondents. The varieties in the various lists are named in alphabetical order. The relative importance of most of the principal varieties in each State is shown in figure 2 and Table III. It should be stated further that in many instances counties not included in the areas of commercial production are reported by the last census to have a larger number of trees than other counties designated as

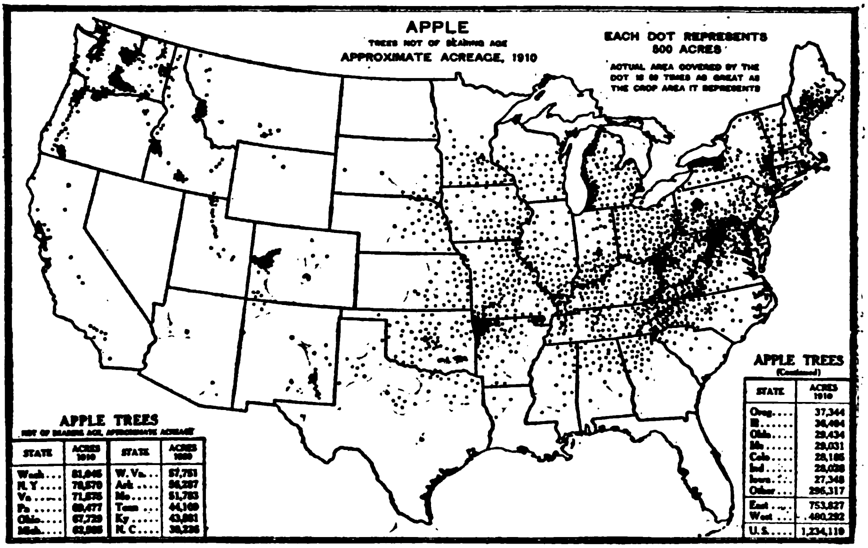

FIG. 10.—Outline map of the United States, showing the approximate distribution of apple orchards of nonbearing age in 1910. Each dot represents 500 acres.

having commercial interests. The explanation is that a comparatively few thousand trees, if planted in a few relatively large orchards in some locality, may make a community industry of considerable size, while an equal or even a much larger number of trees widely distributed in a county in small home orchards would be entirely without commercial significance.

The order in which the different States are mentioned follows the grouping used in the reports of the Thirteenth Census.

## NEW ENGLAND STATES.

### MAINE.

*Distribution.*—Apples are grown somewhat generally throughout the southern half of Maine, with no special centers of production. They are of small relative importance as a crop in the northern sections. Most orchards are on farms where general agriculture is practiced, few specializing in apple growing. The section in which apples are of most importance includes all counties in the southern part of the State, extending as far north as and including practically all of Franklin County and the southern parts of Somerset, Piscataquis, Penobscot, and Hancock Counties.

*Varieties.*—Baldwin, Ben Davis, Gravenstein, McIntosh, Milden, Northern Spy, Oldenburg, Rhode Island Greening, Rolfe, Stark, and Tompkins King. In the northern sections of Maine, Dudley, Fameuse, and Wealthy are of value because of their hardiness. The Ben Davis, though it has been profitable with some growers, is not to be recommended generally for planting in the northern apple-growing sections.

### NEW HAMPSHIRE.

*Distribution.*—Apple growing is more or less general throughout most parts of New Hampshire. The commercial orchards are in the southern half of the State and are quite widely distributed in the southern portions of Grafton and Carroll Counties and southward, with important centers of production located near the central parts of Hillsboro and Merrimack Counties, in the eastern part of Hillsboro extending into the southwestern part of Rockingham County, with a fourth section in the eastern part of Rockingham County.

*Varieties.*—Baldwin, Hubbardston, McIntosh, Rhode Island Greening, Northern Spy, Tompkins King, and Wealthy.

### VERMONT.

*Distribution.*—While farm orchards occur more or less generally in Vermont, the principal commercial interests are in Grand Isle County, centering about Isle La Motte, Grand Isle, and South Hero, the western parts of Chittenden and Addison Counties bordering on Lake Champlain, the southwestern part of Bennington County, and the southern and eastern sections of Windham County.

*Varieties.*—Arctic, Baldwin, Ben Davis,[1] Fameuse, McIntosh, Northern Spy, Rhode Island Greening, Tolman, and Wealthy.

### MASSACHUSETTS.

*Distribution.*—Doubtless apple growing is more generally distributed throughout Massachusetts than in any previously mentioned State. Relatively important areas are indicated as follows:

(1) Western Franklin County, centering about Heath, Colerain, Ashfield, and Buckland.

(2) Northeastern Worcester County, centering about Leominster, Fitchburg, Bolton, and Harvard.

(3) Western Middlesex County, centering about Hudson, Marlboro, Boxboro, and Littleton (this area being the eastern extension of area 2, and parts of Essex County.

(4) Central Berkshire County.

(5) Central parts of Hampshire and Hampden Counties.

*Varieties.*—In area 1, Baldwin, Northern Spy, and Rhode Island Greening are the principal sorts. In area 2, same as area 1; also McIntosh, Red Astrachan, Wealthy, and Yellow Transparent. In areas 3, 4, and 5, same as in area 2; also Gravenstein, Oldenburg, and Roxbury. The Hubbardston and Williams are also grown in some parts of the State.

### RHODE ISLAND.

*Distribution.*—Apples are grown commercially to some extent throughout Rhode Island. The larger interests are in Providence County (centering in Johnston, Smithfield, Foster, and Cumberland Townships), and in Richmond Township in Washington County.

*Varieties.*—Baldwin, McIntosh, Northern Spy, Rhode Island Greening, and Wagener.

### CONNECTICUT.

*Distribution.*—Apple growing is not centralized in Connecticut, but relatively large orchards are located in nearly every county. Some of the more important townships from the standpoint of the apple industry are Danbury and Greenwich in Fairfield County; Cheshire, Milford, Oxford, and Wallingford in New Haven County; Durham and Middlefield in Middlesex County; Cornwall and Salisbury in Litchfield County; Farmington, Glastonbury, and Southington in Hartford County; Woodstock in Windham County.

*Varieties.*—Baldwin, Fall Pippin, McIntosh, Rhode Island Greening, Roxbury, Tompkins King, and Wealthy.

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[1] See under "Maine" (p. 14) for comment regarding Ben Davis.

## MIDDLE ATLANTIC STATES

### NEW YORK.

*Distribution.*—Reference to the diagram in figure 2 and the map (fig. 8) will emphasize the relative importance of New York as compared with other States in the quantity of apples produced. They are grown widely throughout most parts of the State, but the areas which are of great commercial importance are fairly definite, being located in the Hudson River valley and in the western part of the State. The former region consists essentially of the parts of Putnam, Orange, Dutchess, Ulster, Columbia, and Green Counties that are within a comparatively short distance of the river. In the western part of the State the counties that border Lake Ontario—Niagara, Orleans, Monroe, Wayne, Cayuga, and the western portion of Oswego—comprise the famous western New York apple district, though in reality this district also includes parts of Genesee and Livingston Counties (which are in the second tier of counties from Lake Ontario) and a large number of important orchards located about the "finger lakes" in central-western New York. It is to be observed also by referring to the acreage maps (figs. 9 and 10) that there are interests of some importance in the Lake Champlain section and in the St. Lawrence Valley. The fruit from the last two sections, however, does not enter largely into the trade.

*Varieties.*—Baldwin, Fall Pippin, Gravenstein, Hubbardston, McIntosh, Northern Spy, Oldenburg, Rhode Island Greening, Roxbury, Tompkins King, Twenty Ounce, Wagener, and Wealthy.

The Rome Beauty and Boiken were included in a list suggested for Livingston County. The Yellow Newtown is grown successfully in restricted localities in the Hudson River valley. It is of interest to note that the Ben Davis, though comprising 5 per cent of the crop of the State (Table III), was not named by any of the correspondents reporting in this connection.

### NEW JERSEY.

*Distribution.*—Conditions are well suited to the growing of apples in most sections of New Jersey, especially in the central and northern parts. The chief commercial activities, except as they may be represented by individual orchards in other parts of the State, are located in Burlington, Monmouth, Camden, and Gloucester Counties, in which Riverton, Moorestown, Marlton, Middletown, Red Bank, Merchantville, and Glassboro represent important points of production.

*Varieties.*—A larger number of varieties have an important commercial status in New Jersey than in many States, because of the development of relatively large summer-apple interests. The principal sorts are as follows: Baldwin, Ben Davis, Fall Pippin, Gravenstein, Grimes, Jonathan, Maiden Blush, Oldenburg, Red Astrachan, Rome Beauty, Smokehouse, Starr, Stayman Winesap, Wealthy, Williams, Winesap, Yellow Transparent, and York Imperial.

Perhaps no variety is in a larger number of orchards in New Jersey than Smith Cider; but it occurs only in those planted at a comparatively early period, having been dropped entirely in the more recently planted orchards. It is the conviction of some that the McIntosh and Arkansas (or Paragon)[1] will increase in importance as the younger orchards develop. Though not generally planted in New Jersey, the English Codlin has proved quite profitable in some of the early apple orchards in Monmouth County, while the Baldwin is of value chiefly in the northern sections of the State.

### PENNSYLVANIA.

*Distribution.*—In 1910, when the last census was taken, Pennsylvania, on a State basis, ranked sixth in the combined number of bearing and nonbearing apple trees, and the crop of 1909 fell only slightly below that of New York, which ranked first in production. The wide distribution throughout the State is indicated by the fact that only six counties were reported to have less than 40,000 trees each of bearing age. Yet the commercial interests, so far as interstate shipments are concerned, are relatively small, and the centers of production correspondingly difficult to define. Probably the interests in York, Adams, Franklin, and Bedford Counties, in the south-central part, are more generally recognized in the commercial apple industry than are those in most other parts of the State. Luzerne County, in east-central Pennsylvania, also contains interests of considerable extent.

On account of the great number of large industrial towns in Pennsylvania the opportunities for growers of fruit and vegetables to cater to local markets are exceptionally good, and no doubt this accounts in a measure for the fact that so few definite centers of commercial production have been developed.

*Varieties.*—There are at least two fairly definite pomological regions in Pennsylvania. Three such regions are sometimes recognized. In general, the northern half of the State represents what is sometimes termed the Baldwin–Rhode Island Greening–Northern Spy territory, and the southern half represents the Ben Davis–York Imperial–Winesap area.

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[1] Arkansas and Paragon are so nearly alike that it is practically impossible to distinguish definitely the fruit of the one from the other.

A list of varieties that has been suggested for Luzerne County, located in the northern region, in order to provide for a long sequence in ripening, is as follows: (9)[1] Baldwin, (4) Gravenstein, (7) McIntosh, (3) Oldenburg, (2) Red Astrachan, (6) Smokehouse, (10) Stark, (8) Wagener, (5) Wealthy, (1) Yellow Transparent.

In the southern part of Pennsylvania the following varieties predominate in the commercial orchards: Stayman Winesap, York Imperial, Rome Beauty, and Grimes.

Many other varieties occur in Pennsylvania, but the ones named are especially important. Mention in this connection should be made of the Rhode Island Greening and Northern Spy (which occur in the northern part of the State and amount to 5.5 per cent and 11.4 per cent, respectively, of the crop) and the Ben Davis (which occurs more or less generally and which amounts to 6 per cent of the crop).[2] These varieties, however, are evidently in the older orchards, as they do not appear to be commonly recommended for planting anywhere in this State at the present time.

## EAST NORTH-CENTRAL STATES.

### OHIO.

*Distribution.*—Commercial apple growing in Ohio is largely in the southern and southeastern part of the State in the counties bordering the Ohio River and in the counties in the northern part which are influenced by the proximity of Lake Erie. There are interests also of some recognized importance in the central sections of the State. The counties especially mentioned are as follows:

In the Ohio River valley: Belmont, Monroe, Noble, Washington, Athens, Meigs, Gallia, Jackson, Lawrence, Clermont, and Hamilton.

In the central sections: Ross, Fairfield, Franklin, and Delaware.

In the northern part: Lake, Erie, Sandusky, Ottawa, Lucas, and Seneca.

*Varieties.*—For the northern sections: Baldwin, Ben Davis, Grimes, Jonathan, Northern Spy, and Rhode Island Greening. For the central and southern sections, Rome Beauty (especially in addition to Ben Davis and Grimes named above). Stayman Winesap may also be expected to give good results in these sections of the State.

### INDIANA.

*Distribution.*—Apple growing is generalized in Indiana. The interests are widely distributed in the northern and eastern tiers of counties, in the counties in the north-central part of the State through which the Wabash River flows, in the Wabash, White, and White Water River valleys, and generally throughout the southern half of the State. There are two sections of Indiana in which apples are of little importance, namely, the central part south of the Wabash River and the northwestern part which lies between the counties through which the Wabash River flows and the northern tier of counties.

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[1] The number in parentheses preceding each name indicates its sequence of ripening as related to the others in the list.

[2] See Table III for the percentages of other varieties.

*Varieties.*—Ben Davis, Grimes, Indiana Favorite, Jonathan, Rome Beauty, Stark, Wealthy, Winesap, and Yellow Transparent. The varieties not here included which are named for northern Ohio are grown more or less also in northern Indiana. The relative importance of several of them is shown under "Indiana" in connection with Table III.

### ILLINOIS.

*Distribution.*—There are three general areas in Illinois in which the larger commercial apple interests are centralized. The most important development in its extent includes Clay County in the south-central part of the State, which has the largest acreage devoted to apple growing of any county in the State; Wayne, Marion, Richland, Jasper, and Crawford Counties, in all of which there are large acreages; and Cumberland, Jefferson, and Washington Counties, in which smaller interests are located. The second region in importance is in the west-central part of the State and includes Hancock, Adams, Pike, and Calhoun Counties, all of which border on the Mississippi River, and Greene and Jersey Counties, which are adjacent to Calhoun on the east. A third area fairly well defined is in the extreme southern part of the State and consists of the following counties: Jackson, Williamson, Saline, Gallatin, Union, Johnson, Pope, and Massac. In addition to these three somewhat well-defined areas, there are important individual orchards in a number of other counties, including Champaign, Dewitt, Macon, McLean, Bureau, and perhaps others.

*Varieties.*—The principal varieties for most parts of Illinois are Ben Davis, Grimes, Jonathan, and Rome Beauty. In the extreme southern counties, in addition to the first three named, Stayman Winesap, Winesap, and York Imperial are important sorts.

In Marion County, summer apples are grown quite extensively. Yellow Transparent, Oldenburg, and Benoni are especially important varieties.

Other varieties of more or less general importance in most sections of the State include Early Harvest, Red June, Maiden Blush, and Wealthy for early, and Gano, Minkler, Willowtwig, and a few others for long-keeping sorts.

### MICHIGAN.

*Distribution.*—The commercial apple interests in Michigan extend throughout the western portion of the State from Berrien County in the southwest to the Grand Traverse region in the northwest. This region covers approximately the first and second tiers of counties from Lake Michigan as far north as Manistee County, one tier northward from and including that county, and Benzie, Leelanau, and parts of Grand Traverse, Antrim, and Charlevoix Counties. Oakland County, in the southeastern part of the State, also contains large apple interests, as well as several others in the two southern tiers. Besides the regions thus indicated, orchards of commercial standing occur in most sections of the lower peninsula. Apples are of comparatively little commercial importance in the northern peninsula.

*Varieties.*—Baldwin, Fameuse, Grimes, Hubbardston, Jonathan, McIntosh, Maiden Blush, Northern Spy, Oldenburg, Red Canada, Rhode Island Greening, Tompkins King, Wagener, Wealthy, and Yellow Transparent.

The relative commercial importance of the above varieties is suggested with fair accuracy by the percentages given in Table III.

### WISCONSIN.

*Distribution.*—A large part of the apples produced in Wisconsin are grown in home orchards, a considerable proportion of which are in the counties in the southeastern part of the State bordering on Lake Michigan. Commercial interests of considerable extent are located in Door County, north of the channel, including Washington Island, and north of the Wisconsin River in the southwestern part of the State, in Crawford, Richland, and Sauk Counties. Commercial orchards also occupy a relatively small area in the Bayfield Peninsula in the extreme northern part of the State, where the ameliorating influence of Lake Superior on the winter temperatures makes possible the production of fruits which it is quite impossible to grow in other northern parts of the State.

*Varieties.*—Dudley, Fameuse, McIntosh, McMahon, Northwestern, Oldenburg, and Wealthy.

The secretary of the Wisconsin Horticultural Society reports that only such varieties as Hibernal, Malinda, Oldenburg, Longfield, and Charlamoff are hardy north of parallel 45° except in the Bayfield Peninsula region.

## WEST NORTH-CENTRAL STATES.

### MINNESOTA.

*Distribution.*—While some of the very hardy varieties of apples are quite widely grown throughout the southern sections of Minnesota, the commercial interests, which are not extensive, are rather definitely confined to the southeastern part of the State. Probably the most important section is the Minnetonka Lake region in Hennepin and Carver Counties, but orchards of some commercial importance occur in the counties that comprise a triangular area in the southeastern part of the State that is bordered by the Mississippi River, extending as far north as and including Wright County, and on the west in a general way by a line passing from that county through the eastern part of Jackson County, which is in the south-central part of the State. This area is indicated on the map (fig. 8).

*Varieties.*—The varieties chiefly grown are the hardy sorts—Hibernal, Northwestern, Oldenburg, Patten, Scott Winter, Wealthy, and Wolf River.

Considerable attention has been given to the possibility of growing some of the tenderer but higher quality varieties by top-working them on hardy varieties, such as Patten, Wealthy, and the Virginia crab. So handled, such varieties as Banana, Grimes, and Jonathan have been grown, with promise of considerable success.

### IOWA.

*Distribution.*—Apple growing is distributed rather generally in Iowa, being appreciably more extensive in the southern than in the northern part, with the chief commercial interests in the southwestern section in Fremont, Page, Taylor, Mills, Pottawattamie, and Harrison Counties.

*Varieties.*—For northern Iowa, where resistance to severe winter conditions is an essential tree quality: Brilliant, Malinda, Northwestern, Oldenburg, Patten, Salome, Wealthy, and Windsor. For southern Iowa, where the principal commercial interests are located: Ben Davis, Grimes, Gano, Jonathan, Stayman Winesap, and Winesap.

The following is a list of varieties (named in the approximate order in which they ripen) suitable for planting in most parts of the State where a continuous supply of fruit from early to late is desired for home use: Yellow Transparent, Livland, Oldenburg, Charlâmoff, Whitney, Benoni, Dyer, Wealthy, Brilliant, Patten, Ramsdell (sweet), Fameuse, McIntosh, Northwestern, Black Annette, Tolman (sweet), and Windsor.

### MISSOURI.

*Distribution.*—The Thirteenth Census reported for Missouri nearly 3,000,000 more apple trees of bearing age than for any other one State, and it was exceeded by only two States in the number of trees not of bearing age. This naturally means a very general distribution of apples throughout the State, as is indicated by the maps (figs. 8, 9, and 10). However, there are certain sections in which the more important commercial interests have been developed. Of these the Ozark region in the southwestern part of the State is doubtless the most widely known. The orchards in this region are located largely in McDonald, Newton, and Lawrence Counties, and in those through which the St. Louis and San Francisco Railroad passes, including Greene, Webster, Wright (southern part), Texas (southwestern part), Howell, and Oregon (southwestern part). In the northwestern part of the State, Holt, Andrew, Buchanan, Platte, and Clay Counties form a portion of an important district which is made up of this portion of northwestern Missouri and adjacent sections of northeastern Kansas, southeastern Nebraska, and southwestern Iowa.

There are also important localities in other counties in Missouri (bordering on the Missouri River), of which Jackson, Lafayette, Carroll, Saline, and Howard may be especially mentioned. Pike County, which borders on the Mississippi River in the northeastern quarter of the State, also has large interests.

*Varieties.*—Many varieties are grown in the commercial orchards, but the leading ones are Arkansas (*Mammoth Black Twig*), Ben Davis, Delicious, Gano, Grimes, Ingram, Jonathan, Missouri (*Missouri Pippin*), Winesap, and York Imperial.

### NORTH DAKOTA.

*Distribution.*—Apples are not grown commercially in North Dakota, except as they may be marketed locally in small quantities from some of the small ranch orchards.

*Varieties.*—The hardy varieties suggested for northern Wisconsin and for Minnesota include those commonly planted in the limited extent to which apples are produced in this State.

### SOUTH DAKOTA.

*Distribution.*—Apple growing can hardly be termed a commercial industry in South Dakota, yet the conditions in a considerable portion of the State admit of maintaining small home orchards, which supply more or less fruit for local markets.

The State Horticultural Society divides the State into four districts: Northern—that part north of a line running east and west through Watertown; central—that part between the northern district and a line running east and west through Sioux Falls; southern—the part south of the central district; Black Hills—the area in the southwestern part of the State commonly known by this name.

It is claimed that in the seven or eight counties in the extreme southeastern corner of the State more apples are grown than in all the rest of the State outside the Black Hills district.

*Varieties.*—The State Horticultural Society names the following for the different districts:

*Northern district.*—First degree of hardiness, Hibernal and Oldenburg; second degree of hardiness, Anisim, Patten, and Wealthy.

*Central district.*—Same as for the northern district, with Malinda added to the second group.

*Southern district.*—Anisim, Iowa Blush, Malinda, Northwestern, Oldenburg, Patten, and Wealthy.

*Black Hills district.*—Summer: Tetofski, Yellow Transparent, Charlamoff, and Oldenburg. Fall: Wealthy, Okabena, Longfield, Wolf River, and Patten. Winter: McIntosh, Ben Davis, and Gano.

The following varieties are also recommended for trial generally throughout the State: Dudley, Iowa Beauty, Livland, Longfield, Milwaukee, and Yellow Transparent. The Hibernal is especially recommended as a hardy stock upon which to top-work other varieties.

### NEBRASKA.

*Distribution.*—Home orchards occur widely throughout a large portion of Nebraska, but especially in the eastern half. The commercial interests are quite definitely located in the southeastern section and are largely in the following counties: Richardson, Pawnee, Nemaha, Johnson, Gage, Otoe, Cass, and Lancaster (all south of the Platte River); and Sarpy, Douglas, Saunders, Washington, and Burt (north of the Platte and bordering on the Missouri River).

*Varieties.*—The principal commercial varieties are Arkansas, Ben Davis, Gano, Grimes, Jonathan, Missouri, Wealthy, Winesap, and Oldenburg.

For general planting, the above-named varieties may be used in a large portion of the State. The winter varieties in the list are the ones commonly found in the home orchards. The State Horticultural Society suggests for most sections the following: For early ripening—Benoni, Early Cooper, Early Harvest, Red Astrachan, and Yellow Transparent. For fall ripening—Dyer, Maiden Blush, Plumb Cider, and Utter. For sections where the conditions are especially severe, the varieties named for the southern section of South Dakota are suggested in the present connection.

### KANSAS.

*Distribution.*—So far as the general distribtuion of apples in Kansas is concerned, the conditions are not materially different from those in Nebraska. There are two fairly well-defined regions of commercial interest. One of these is in the northeastern corner of the State, and this, with contiguous areas in the adjacent States, makes up a region in which great commercial interests are located. The part of this region in Kansas consists primarily of the following counties: Doniphan, Brown, Nemaha, Atchison, Jackson, Wyandotte, Leavenworth, Jefferson, Shawnee, Johnson, Douglas, Miami, Franklin, and Linn.

The second region is in the Arkansas River valley in Reno, Sedgwick, Cowley, and Sumner Counties. In this region the principal orchards are located within a comparatively short distance of the river.

It should also be added that there are large orchards in many other counties in the eastern part of the State, especially south of the Kansas River, but they do not represent the heavy concentration of orchard interests that prevails in the regions designated. Morris, Lyon, and Greenwood Counties are representative of this latter group.

*Varieties.*—Arkansas, Ben Davis, Early Cooper, Gano, Grimes, Jonathan, Maiden Blush, Missouri, Rome Beauty, Stayman Winesap, Winesap, and York Imperial. The Delicious is also giving promising results in some of the younger orchards in both of the principal commercial regions. In the Arkansas River valley the King David is highly regarded by some growers.

## SOUTH ATLANTIC STATES.

### DELAWARE.

*Distribution.*—Apple growing is rather general in Delaware, with the largest commercial interests located in the central part of the State in Kent County. Wyoming is probably the largest shipping point. Dover, Smyrna, and Felton are other points having interests of considerable magnitude. Middletown in Newcastle County and Bridgeville in Sussex County are also centers of some importance.

*Varieties.*—Summer-apple growing is a prominent phase of the industry. The following early sorts are largely grown: Yellow Transparent, Early Ripe, Red Astrachan, and Williams (*Williams Early Red*). The principal long-keeping varieties are Arkansas (or Paragon),[1] Ben Davis, Jonathan, Nero, Rome Beauty, Stayman Winesap, Winesap, and York Imperial. Grimes is reported from the vicinity of Middletown and King David from the Wyoming section.

### MARYLAND.

*Distribution.*—The leading apple-producing counties in Maryland are Allegany, Washington, Frederick, Montgomery, and Kent. The commercial interests are somewhat widely distributed in these counties, while individual orchards of considerable importance occur in many other parts of the State.

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[1] See footnote under "New Jersey" (p. 17) for explanation relating to these varieties.

*Varieties.*—Ben Davis, Grimes, Jonathan, Oldenburg, Stayman Winesap, Williams, Winesap, Yellow Transparent, and York Imperial. In some of the Eastern Shore counties the Arkansas (or Paragon) occurs frequently, while in Garrett County, in the extreme western part of the State, where the elevations are high, the Baldwin is a relatively important variety.

### VIRGINIA.

*Distribution.*—The commercial apple-orchard interests in Virginia are located mostly in the Piedmont, Blue Ridge, and Shenandoah Valley regions. In a general way, the statement is accurate that these three regions include the two tiers of counties which extend in a northeast-southwest direction throughout the State and which have a common boundary on the crest of the Blue Ridge Mountains. In some sections where the counties are small, this area is three counties in width. This territory as a commercial apple-producing area may be said to extend as far west as Pulaski and Carroll Counties, but interests of considerable magnitude are being developed in other counties in the southwestern part of the State, including Grayson, Wythe, Smythe, Russell, and possibly others. Several counties in the northern part of Virginia also have orchards of considerable importance individually, but they do not make up community interests of large extent.

*Varieties.*—While many varieties occur, especially in the older orchards, those which largely make up the commercial industry are Arkansas (*Mammoth Black Twig*), Ben Davis, Grimes, Rome Beauty, Stayman Winesap, Winesap, Yellow Newtown (*Albemarle Pippin*)—grown to some extent in the coves, on the spurs, and on the eastern slope of the Blue Ridge—and York Imperial.

### WEST VIRGINIA.

*Distribution.*—There are three regions in West Virginia of particular prominence for commercial apple production. The seven counties that comprise the eastern "panhandle," so-called, form one of these regions, the four eastern counties constituting the more important part. The four counties that constitute the northern panhandle make another region of considerable prominence, Hancock County being the most widely known section of this region. A third region consists of the counties that border on the Ohio River, extending from and including Wayne County on the south to Pleasant County on the north. In this region the orchards are located mostly within a few miles of the river.

The northern panhandle region is in some respects a northern extension of this Ohio River valley region, but the existence of certain climatic differences warrants their recognition as separate regions.

Commercial orchards of some prominence exist in other counties, as in Barbour, Randolph, Greenbrier, and perhaps others, but the interests in them are not heavily centralized.

*Varieties.*—Arkansas (*Mammoth Black Twig*), Baldwin, Ben Davis, Gano, Grimes, Jonathan, Rome Beauty, Stayman Winesap, Wealthy, Willowtwig, and York Imperial.

The Ohio River valley region is characterized by the Rome Beauty; the northern panhandle region by Baldwin and Willowtwig. The eastern region is the northern extension of the Shenandoah Valley region in Virginia.

### NORTH CAROLINA.

*Distribution.*—The commercial apple interests in North Carolina are located in the mountain districts in the western part of the State. The principal centers are in Surry County about Mount Airy; in the Brushy Mountain section, tributary to Northwilkesboro in Wilkes County; and Buncombe and Haywood Counties. As in West Virginia, orchards of considerable size are located in other counties than those named, but as a rule they do not constitute large community interests.

*Varieties.*—Arkansas, Grimes, Limbertwig, Rome Beauty, Royal Limbertwig, Stayman Winesap, Winesap, and York Imperial. In some of the older orchards, especially in Buncombe and Haywood Counties, the Yellow Newtown (*Albemarle Pippin*) occurs more or less, but it is rarely planted in this section at the present time. The Limbertwig occurs mostly in the orchards in Surry and Wilkes Counties. The Ben Davis comprises 7.5 per cent of the total crop of the State; Early Harvest, 7.2 per cent; Horse, 7.2 per cent; and Red June, 5.9 per cent (p. 5), but these varieties apparently are widely distributed and occur more largely in home orchards than in those of commercial size. Though the Ben Davis is in some of the larger orchards, it is apparently a relatively unimportant variety from a commercial standpoint. The Delicious is reported to do well in some sections of western North Carolina.

### SOUTH CAROLINA.

*Distribution.*—The commercial apple interests in South Carolina are relatively small. They are located principally in the extreme western part of the State in Spartanburg, Greenville, Anderson, Pickens, and Oconee Counties.

*Varieties.*—The relatively long-keeping varieties that are considered of particular value in the above-named counties are Arkansas *(Mammoth Black Twig)*, Delicious, Scott Cluster, and Yates. Other varieties more or less popular are Ben Davis, Gano, Shockley, and Winesap. At some of the higher elevations in Greenville, Pickens, and Oconee Counties the Kinnard is valuable. Early Harvest, Horse, and Red June are the principal summer varieties. The early varieties are grown somewhat widely in the central as well as in the western sections of the State.

#### GEORGIA.

*Distribution.*—Apple growing in Georgia on a commercial basis is confined principally to Rabun and Habersham Counties in the northeastern part of the State. A few orchards have been developed in White, Union, Lumpkin, and other counties in northern and northwestern Georgia, where the elevations in the southern extension of the Blue Ridge Mountains are comparatively high. No apples of importance are grown south of Atlanta.

*Varieties.*—Arkansas *(Mammoth Black Twig)*, Arkansas Black, Ben Davis, Kinnard (at the higher elevations), Shockley, Stayman Winesap, Terry, Winesap, Yates, and Yellow Transparent. The Limbertwig (a long-keeping sort) and Early Harvest, Horse, and Red June (summer varieties), taken together, constitute relatively a large percentage of the entire crop of the State, but they do not occur, as a rule, in the commercial orchards. This suggests the fact that, though relatively few apples are grown in Georgia, a large proportion of the total is produced in small home orchards, of which a considerable part consists of the three summer varieties named above.

#### FLORIDA.

Practically no apples are grown in Florida, on account of the mildness of the climate throughout the year.

### EAST SOUTH-CENTRAL STATES.

#### KENTUCKY.

*Distribution.*—The commercial orchards in Kentucky are located mostly at points along the Ohio River, quite largely in Campbell, Kenton, Jefferson, Hardin, Henderson, and McCracken Counties. Individual orchards and relatively small community interests occur in other sections, Warren, Madison, and Bath Counties being representative locations. Formerly there were very extensive orchards of the Ben Davis apple in Meade and Breckinridge Counties, which border on the Ohio River in the north-central part of the State, but to a very considerable extent these orchards have ceased to be of commercial importance.

*Varieties.*—Arkansas (*Mammoth Black Twig*) or Paragon, Ben Davis, Early Harvest, Gano (or *Black Ben*), Grimes, Jonathan, Maiden Blush, Rome Beauty, Stayman Winesap, Winesap, and Yellow Transparent. In some of the older orchards the Limbertwig and Red June occur frequently.

### TENNESSEE.

*Distribution.*—Though apple growing is widely distributed in Tennessee, the activities of commercial importance are fairly well localized. In the lower Cumberland Valley, in Bradley, Hamilton, and Rhea Counties, the interests are considerable. In Knox and several other counties in this valley there are also some orchards. The largest region is in the central part of the State and includes Sumner, Davidson, Williamson, Maury, and Lincoln Counties. Summer apples are grown quite largely in this region; also in Haywood County, in the southwestern part. In Obion County, in the northwestern part, a number of orchards are being developed.

*Varieties.*—The leading commercial summer apples are Early Harvest, Early Ripe, Fanny, Oldenburg, Wealthy, and Yellow Transparent. The later keeping sorts most commonly planted are Ben Davis, Paragon (or Arkansas), Stayman Winesap, Winesap, and York Imperial. In many of the small orchards that have been planted a long time Limbertwig, Horse, and Red June occur.

### ALABAMA.

*Distribution.*—The commercial apple industry in Alabama is of rather small proportions, yet there are a few places where orchards of some importance have been developed. These are located mostly on the mountain ridges or spurs in the northeastern corner of the State. De Kalb and Madison Counties, as well as some others, have such orchards. Farther south, in the east-central part of the State, one variety—the Yates—is said to be grown in some quantity. In the southern half of the State very few apple trees occur.

*Varieties.*—At the higher elevations in northeastern Alabama the Early Harvest and Horse, for summer sorts, are said to do especially well. Longer-keeping varieties commonly planted are Arkansas, Gano (or *Black Ben*), Kinnard, Stayman Winesap, Winesap, and Yates. In certain orchards the Collins and Delicious are considered promising. For locations other than those having relatively high elevations, the San Jacinto, an early sort, apparently not much planted in Alabama, and for later varieties the Terry and Yates may be expected to do well. The Terry is planted quite widely in Georgia. In some sections of the far South the Kinnard also is relatively satisfactory.

### MISSISSIPPI.

*Distribution*.—While a few apple trees occur in many parts of Mississippi, particularly in the northern part of the State, the interests are hardly to be rated as commercial, except as the orchards may supply a little fruit for local markets. Prentiss, Lee, and Pontotoc Counties (all in the northeastern part of the State) have been mentioned as having apple orchards of some extent.

*Varieties*.—The varieties named under "Alabama" are suggested also for the corresponding sections of Mississippi.

## WEST SOUTH-CENTRAL STATES.

### ARKANSAS.

*Distribution*.—The St. Louis, Iron Mountain & Southern Railway, which from the north enters Arkansas near the northeastern corner of the State and passes in a southwesterly direction to Texarkana, which is near the southwestern corner, divides the State in a general way into two approximately equal sections. The portion of the State lying west of the railroad named produces practically all of the apples grown in Arkansas. While they are distributed to a limited extent in the southeastern section, the quantity produced there is negligible. In the northwestern section there are a good many orchards of commercial importance that are widely distributed. However, the apples which are a substantial factor in the trade are produced in five or six counties in the northwestern corner, these counties being Benton, Washington, Carroll, Madison, and Boone. Other counties in the same section of the State which are of secondary importance in apple production are Crawford, Franklin, and Searcy. The commercial orchards which occur in other counties in the northwestern section of the State are more or less isolated and do not represent large unit interests.

*Varieties*.—A large number of varieties occur in the commercial orchards in Arkansas, but a very large proportion of the product consists of the following: Arkansas (*Mammoth Black Twig*), Ben Davis, Gano, Grimes, Jonathan, Maiden Blush, and Winesap. In the younger orchards Stayman Winesap is an important variety, but it has not yet been marketed in large quantities from this State.

### LOUISIANA.

*Distribution*.—A few apples are grown for home use in the northern portion of Louisiana. From a commercial standpoint the quantity of fruit produced is negligible.

*Varieties*.—No special recommendations are made as to varieties aside from those under "Alabama" for locations other than those having relatively high elevations.

### OKLAHOMA.

*Distribution.*—While there are a good many commercial apple orchards in Oklahoma they are rather widely distributed, with no very large centralization of the industry at any one point. With the State divided in a general way into eastern, central, and western thirds, the most of the commercial orchards occur in the central third of the State. Some fairly representative localities in which apples are grown to some extent commercially are Ada in Pontotoc County, Konawa in Seminole County, Guthrie in Logan County, and Enid in Garfield County. The fruit from some of these orchards, as well as from those located in other parts of the State which are somewhat isolated, is sold very largely in local markets.

*Varieties.*—As in many other States, a large number of varieties have been planted in Oklahoma, but the really important sorts consist of a comparatively small number, as follows: Arkansas (*Mammoth Black Twig*), Arkansas Black, Ben Davis, Gano, Grimes, Jonathan, Maiden Blush, Missouri, Red June, Stayman Winesap, Winesap, Yellow Transparent, and York Imperial.

In the south-central part of the State where the summers are long and usually very hot it is believed that the varieties suggested for the lower elevations in Alabama could be planted with more satisfaction than many of those which now comprise the orchards in that part of the State.

### TEXAS.

*Distribution.*—Apples are relatively unimportant in Texas, though they are more or less widely distributed in the northern third of the State. This includes in a general way that part of Texas which lies north of a line extending from the southeastern corner of New Mexico due east to about the central portion of the State, then somewhat northeasterly to Marion County in the northeastern part of the State. In the section thus indicated there are no large areas devoted to commercial apple production, though a good many orchards of commercial size occur. These are reported to be somewhat centralized in Erath and Eastland Counties, in northern Comanche County, in the southern portion of the first northern tier of counties, and in the northern portion of the second tier of counties in the northeastern part of the State. This territory extends in a general way from Red River County in the east as far westward, possibly, as Baylor County. In the panhandle region interests of some importance have been developed in Hale and Lubbock Counties. In the extreme western part of the State, a section which includes the northern part of Brewster County, the western portion of Pecos County, and eastern part of Jeff Davis County should be mentioned in this connection. Apples are also grown to a limited extent in the region of El Paso.

*Varieties.*—Various lists of varieties have been suggested for different parts of Texas, but there is considerable similarity in them. Some of the more comprehensive lists include a number of varieties not often grown in other States. For northern Texas the following varieties have been recommended: Arkansas (*Mammoth Black Twig*), Arkansas Black, Becker, Bledsoe, Early Harvest, Gano, Jonathan, Kinnard, Lincoln, Missouri, San Jacinto, Stayman Winesap, and Summer Queen.

Other lists for this section of Texas include, in addition to the above, Ben Davis, Doyle, Maiden Blush, Red June, Yellow Transparent, and others. It may be stated also that the lists that have been recommended for other sections of the State consist very largely of different combinations of the varieties named above.

### MOUNTAIN STATES.

In the Mountain States, commercial fruit growing is confined very largely to rather restricted areas in the valleys so located that they can be irrigated. Very few of the commercial orchards in the States in this division are maintained without irrigation.

### MONTANA.

In Montana there are at the present time six fairly well defined valley areas where apples are grown, as follows:

(1) The Bitter Root Valley in Ravalli County and Southern Missoula County, the fruit district extending from Darby to Missoula.

(2) The Flathead Lake district in the southern part of Flathead County, the orchards being located largely on the shores of the lake and extending northward to Kalispell.

(3) The Kootenai Valley in Lincoln County, this valley area extending from Eureka in the north nearly to the border line of the State on the west.

(4) The Clark Fork valley in Sanders County between Plains and Thompson.

(5) The valley of the Clark Fork of the Yellowstone River in Carbon County from Fromberg to the junction of the fork with the Yellowstone.

(6) The Yellowstone River valley in Yellowstone County, centering about Billings.

*Varieties.*—A smaller number of varieties have been planted in the orchards in Montana than is the case in most commercial apple-growing regions. In the areas designated as Nos. 1, 2, 3, and 4, McIntosh, Rome Beauty, and Wealthy are the principal varieties. To a lesser extent, Delicious, and Wagener are planted. In area 2 Tompkins King is also grown. In areas 5 and 6 Gano, McIntosh, and Wealthy are chiefly grown.

### IDAHO.

*Distribution.*—At the present time the most important apple-orchard interests of Idaho are located in the southwestern part of the State. There are several important centers of production, as follows:

*District 1.*—Northern Idaho, which includes two sections, one centering about Bonners Ferry in the extreme northern part of the State and the other about Post Falls in the northern portion of Kootenai County.

*District 2.*—The Palouse region in Latah County, which extends also into Whitman County in eastern Washington.

*District 3.*—The Lewiston region, in Nez Perce County and also in the Snake River valley.

*District 4.*—The Council Valley, extending between Council and Weiser.

*District 5.*—The Payette Valley, centering about Payette and Emmett.

*District 6.*—The Boise Valley, with centers of production about Caldwell, Nampa, and Boise.

*District 7.*—The Snake River canyon region, which includes that portion of the Snake River valley which lies between the point where the river crosses the State line into Oregon and the Twin Falls region, where, at various points in the coves made by the river, orchards of some importance have been planted.

*District 8.*—The Snake River valley, in the Twin Falls region in the south-central part of the State.

*District 9.*—The Blackfoot and Idaho Falls region in the Snake River valley, in the southeastern part of the State.

*Varieties.*—The varieties in the following list, with numbers corresponding to those used to designate the several districts, include the more important sorts:[1]

*District 1.*—Banana (*Winter Banana*), Jonathan, Rome Beauty, Tompkins King, and Wagener.

*District 2.*—Jonathan, Grimes, Rome Beauty, and Wagener.

*District 3.*—Delicious, Esopus (*Spitzenberg*), Jonathan, Rome Beauty, Winesap, and Yellow Newtown.

*Districts 4, 5, and 6.*—Arkansas Black, Ben Davis, Delicious, Gano, Jonathan, Rome Beauty, and Winesap.

*District 7.*—Delicious, Gano, Jonathan, Rome Beauty, and Winesap.

*District 8.*—Delicious, Grimes, Jonathan, Rome Beauty, Stayman Winesap, Wagener, and Winesap.

*District 9.*—Gravenstein, McIntosh, and Wealthy.

A considerable number of other varieties are mentioned in Bulletin 83 of the Idaho experiment station[1] as being of secondary importance in each of the districts. For the northern districts the principal secondary varieties are Baldwin, Gravenstein, Grimes, Northern Spy, Oldenburg, Wolf River, Yellow Bellflower, and Yellow Transparent. For the other districts, the following comprise the principal secondary varieties where not named in the lists of first importance: Banana, Early Harvest, Gravenstein, McIntosh, Oldenburg, Rhode Island Greening, Stayman Winesap, White Pearmain, and Wealthy.

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[1] The varieties here listed for the various districts are substantially those recommended by the Idaho Agricultural Experiment Station. (Vincent, C. C., and Downing, G. J., Recommended varieties of fruit for Idaho. Idaho Agr. Exp. Sta. Bul. 83, 14 p., map. 1915.)

The following varieties comprise the principal ones grown in the State on the basis of the relative quantity of each in the average crop for all the districts: Ben Davis, Jonathan, Tompkins King, Rome Beauty, and Winesap. (See p. 7.)

### WYOMING.

*Distribution.*—As yet practically no commercial fruit growing has been developed in Wyoming. In a few sections where apples are grown the fruit is sold in local markets, but elsewhere the fruit is produced only in small ranch orchards for home use. The most important apple-orchard interests are located in the valley of the Bighorn River and its tributaries in Bighorn, Washakie, and Hot Springs Counties; also in the valley of the Platte River in Natrona, Converse, Platte, and Goshen Counties. Orchards more or less widely separated also occur in Crook, Johnson, and Sheridan Counties in the northeastern portion of the State.

*Varieties.*—Because of the rather adverse climatic conditions, only the more hardy varieties succeed. Those most planted are Longfield, Northwestern, Wealthy, and Wolf River. Doubtless other hardy varieties named under South Dakota and also for the northern sections of Minnesota and Wisconsin could be grown with some degree of success.

### COLORADO.

*Distribution.*—There are several well-defined valleys or areas in Colorado where apples are of large commercial importance, as follows:

(1) The northern district includes the eastern portion of Larimer and Boulder Counties, the northeastern portion of Jefferson County, the western portion of Arapahoe and Adams Counties, and the southwestern portion of Weld County.

(2) The southeastern district is located in the Arkansas River valley and extends, with some breaks in the continuity of the orchards, from the Canon City section in Fremont County nearly to the eastern border of the State, although comparatively few orchards of importance have been planted east of Otero and Crowley Counties.

(3) The southwestern district may be said to consist of two sections, one of which is in the northeastern portion of Montezuma County and the other in the central and northern portion of La Plata County, extending somewhat into San Juan County.

(4) The west-central district consists of the Grand Valley (extending from Palisades to Fruita), the Uncompahgre Valley (extending from Delta and adjacent sections to Montrose), and the valley of the North Fork of the Gunnison, with important centers of production at Paonia and Hotchkiss.

There are other points in the valley of the Grand River above Palisades where apples are grown to some extent, Grand Valley, Rifle, and Antlers being representative points where there are orchards of commercial standing. Aside from these disticts, where the commercial apple interests are large, the fruit is grown for home use in other parts of the State, though where water for irrigation is not available the conditions do not admit of commercial activities except in special instances.

*Varieties.*—The varieties suggested for the several commercial districts mentioned are as follows:

*Northern district.*—Ben Davis, Gano, Jonathan, Ralls (*Jeniton*), and Sheriff.

*Southeastern district.*—Maiden Blush, Jeffery, Jonathan, White Pearmain, and Winesap.

*Southwestern district.*—Delicious, Jonathan, White Pearmain, and Winesap.

*West-central district.*—Arkansas (*Mammoth Black Twig*), Arkansas Black, Ben Davis, Delicious, Gano, Jonathan, Rome Beauty, Stayman Winesap, and Winesap.

The leading varieties for the entire State, as indicated by the proportion of each in the average crop, are as follows: Ben Davis, Jonathan, Gano, Rome Beauty, and Winesap. (See under "Colorado" in connection with Table III.)

## NEW MEXICO.

*Distribution.*—The commercial production of apples in New Mexico is limited to certain irrigated valleys. These districts have been clearly defined by Garcia, of the New Mexico Agricultural Experiment Station, in Bulletin 75.[1] In this bulletin, 10 valleys and sections of valleys in which apples are grown commercially are recognized. Since the bulletin was published in 1910, some of these districts have been extended more or less, and a new district has been developed in the vicinity of Portales, the county seat of Roosevelt County, in the east-central part of the State. The districts recognized are designated as follows:

(1) Mimbres Valley district, located in the eastern portion of Grant County and the central portion of Luna County in the southwestern corner of the State.

(2) Rio Grande Valley district, the largest one recognized, extending from the southern border of the State, in Dona Ana County, to Santa Fe County, in the north-central part of the State.

(3) The Otero County district, in the northern portion of Otero County, in the south-central part of the State.

(4) The Lincoln County district, in the southeastern section of Lincoln County.

(5) Pecos Valley district, extending from Roswell (in Chaves County) to Carlsbad (in Eddy County) in the southeastern corner of the State.

(6) The Colfax County district, in the central portion of Colfax County, in the northeastern part of the State.

(7) The San Miguel district, in the northwestern corner of San Miguel County.

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[1] Garcia, Fabian. Apple culture under irrigation. N. Mex. Agr. Exp. Sta. Bul. 75. 44 p., 14 fig. 1910.

(8) The Santa Fe and Rio Arriba district, in the northern portion of Santa Fe County and the southeastern portion of Rio Arriba County.

(9) The Taos County district, in the central part of Taos County, in the north-central part of the State.

(10) The San Juan County district, in the San Juan River valley, in the northern part of San Juan County, in the northwestern corner of the State.

(11) The Roosevelt County district in the east-central part of the State, which, as already indicated, centers about Portales.

*Varieties.*—In districts 1, 2, 5, and 11: Arkansas (*Mammoth Black Twig*), Arkansas Black, Ben Davis, Gano (or *Black Ben*), Jonathan, Red June, Winesap, and Yellow Transparent. In districts 3, 4, 6, 7, 8, 9, and 10: Delicious, Gano (or *Black Ben*), Jonathan, Maiden Blush, Rome Beauty, Stayman Winesap, White Pearmain, Winesap, and Yellow Transparent.

### ARIZONA.

*Distribution.*—While apple orchards occur in various portions of Arizona, the principal districts in which they are of commercial importance are in the valley of the Gila River, in Graham County (in the southeastern portion of the State), and in the valley of the Verde River, in the eastern portion of Yavapai County (in the center of the State).

*Varieties.*—In the Gila Valley: Arkansas Black, Ben Davis, Gano (or *Black Ben*), and Stayman Winesap. In the Verde Valley: The varieties named above; also Jonathan and White Pearmain.

### UTAH.

*Distribution.*—Commercial apple growing in Utah is confined principally to three irrigated valleys in northern portions of the State. In the northeastern part, in the Cache Valley, along the western slope of the Wasatch Mountains, many apples are grown; also in the valleys lying north of Great Salt Lake, in the eastern portion of Box Elder County. A third valley is in Davis County, between Great Salt Lake and the western slope of the Wasatch Mountains. This valley is practically a continuation of the Cache Valley. In some of the small irrigated valleys in other sections of Utah minor apple interests have been developed, but they are not of special importance commercially.

*Varieties.*—The varieties grown principally are Ben Davis, Gano, Jonathan, Rome Beauty, and Winesap. In some sections the Ben Davis and Gano (or *Black Ben*) are now much less prominent than they were formerly.

### NEVADA.

*Distribution.*—A few apples are grown in some sections of Nevada for home use, but there is no commercial apple industry in this State at the present time.

## PACIFIC STATES.

### WASHINGTON.

*Distribution.*—The principal commercial apple interests in Washington are located in irrigated valleys east of the Cascade Mountains, the principal centers of which are the following:

(1) The Yakima Valley, in Yakima County and the western part of Benton County.

(2) The Wenatchee Valley, extending in Chelan County from Peshastin to Wenatchee and bordering on the Columbia River to Malaga.

(3) The area about the junction of the Columbia and Snake Rivers, which form the boundaries between Walla Walla, Franklin, and Benton Counties.

(4) The Walla Walla Valley, in the vicinity of Walla Walla.

(5) The Snake River valley, along the borders of Garfield, Columbia, and Whitman Counties.

(6) The Clarkston district, in the northern portion of Asotin County, which with the Lewiston district in Idaho comprises the Lewiston-Clarkston district, as it is commonly called.

(7) The Palouse district, in the eastern part of Whitman County, which, together with a corresponding section in Latah County, Idaho, comprise a more or less important district.

(8) The Spokane district, which comprises an area that includes the Post Falls district in Idaho, the northern portion of Spokane County, the southern part of Pend Oreille County, and the southwestern portion of Stevens County.

(9) The Columbia River valley, in the northern portion of Stevens and Ferry Counties.

(10) The Okanogan Valley, in Okanogan County.

(11) The Lake Chelan district, which may also be made to include certain points in the Columbia River valley where it is the boundary between Douglas and Chelan Counties between Lake Chelan and Wenatchee.

(12) The White Salmon district, in the southwestern part of Klickitat County.

(13) The Puget Sound region, where apples are grown in the aggregate in quite large quantities, but do not constitute an industry of the same commercial purport as do the interests in the larger valleys east of the mountains.

*Varieties.*—The principal varieties produced in most of the commercial areas are Arkansas, Arkansas Black, Ben Davis, Banana, Delicious, Esopus (*Spitzenberg*), Gano, Grimes, Jonathan, Rome Beauty, Stayman Winesap, White Pearmain, Winesap, and Yellow Newtown. In the Puget Sound district, Baldwin, Gravenstein, Northern Spy, Rhode Island Greening, Tompkins King, and various other varieties commonly occur. The Esopus (*Spitzenberg*) and Yellow Newtown are grown only to a limited extent, and are unimportant varieties in most of the districts in Washington.

### OREGON.

*Distribution.*—The fruit districts of Oregon are fairly definitely delimited. With slight exceptions they are confined to certain irrigated valleys as follows:

*East of the Cascade Range.*—(1) The Grande Ronde Valley, in the central part of Union County; (2) the Walla Walla Valley, in the Milton-Freewater section in Umatilla County; (3) the Hood River valley, in Hood River County, including the Mosier Valley in the northwestern corner of Wasco County; (4)

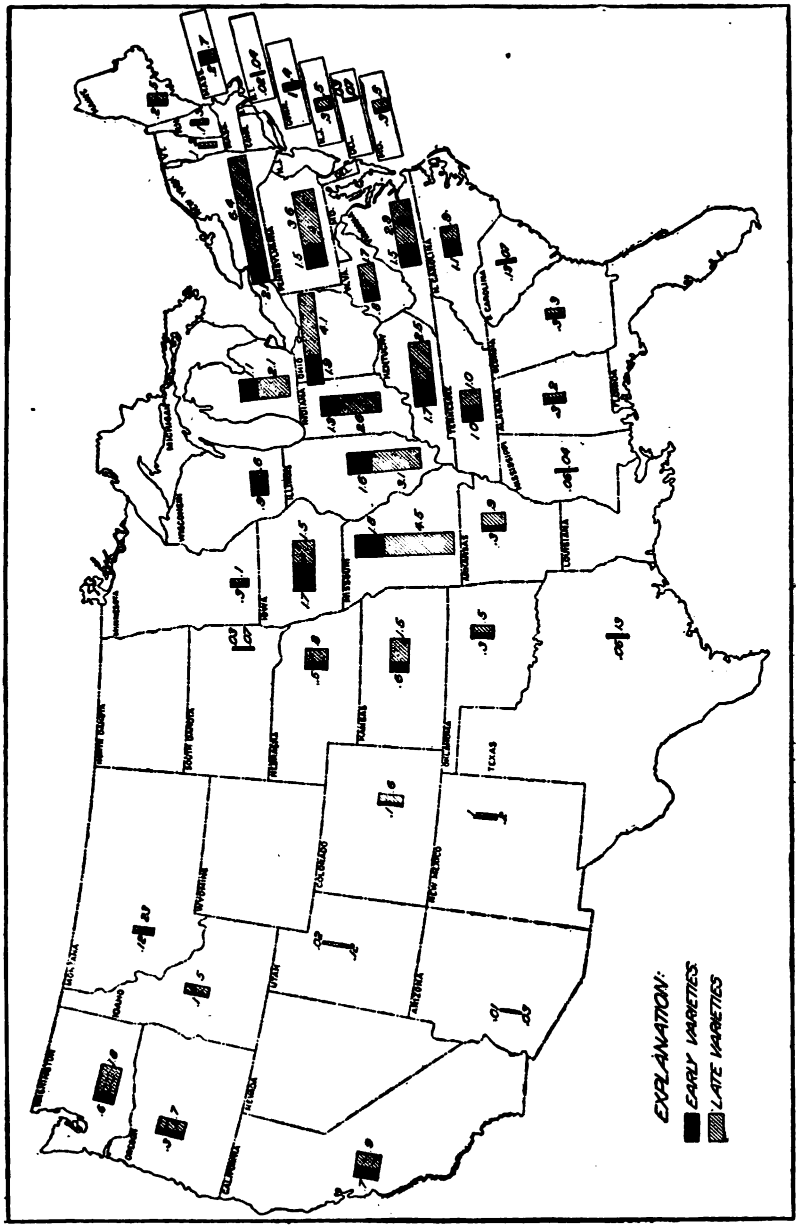

FIG. 11.—Outline map of the United States, showing the estimated relative production of early and late varieties in each State in 1915. The black portion of the bars represents early varieties; the crosshatched portion, late varieties. The figures represent the estimated number of barrels on the basis of 1,000,000.

The Dalles section, also in Wasco County, a section relatively unimportant so far as apples are concerned, the stone fruits comprising most of the fruit industry.

*West of the Cascade Range.*—(5) The Willamette Valley; (6) the Umpqua Valley, in the central part of Douglas County; (7) the Rogue River valley, in the eastern part of Josephine County and the central part of Jackson County.

*Varieties.*—There is more or less uniformity in the important varieties in the different valleys. However, the leading ones in some sections are unimportant in others. The following lists are based largely on recommendations of the Oregon Agricultural Experiment Station:[1]

*District 1.*—Ben Davis, Gano, Rome Beauty, Tompkins King, Wagener, and York Imperial; some Banana and Delicious in the younger orchards.

*District 2.*—Jonathan, Rome Beauty, and Winesap; in older orchards, Ben Davis also, but the trees are being top-worked more or less to other varieties.

*District 3.*—Esopus (*Spitzenberg*) and Yellow Newtown are most important; Arkansas Black, Jonathan, Monmouth (*Red Cheek*), and others occur to some extent.

*District 4.*—The few apples grown in this section (The Dalles) consist largely of the Baldwin, Ben Davis, Esopus (*Spitzenberg*), Winesap, and Yellow Newtown.

*District 5.*—On account of its size and the varied conditions in this valley (Willamette) a rather wide range of varieties is grown, the pricipal ones being Baldwin, Esopus (*Spitzenberg*), Gano, Gravenstein, Grimes, Jonathan, Northern Spy, Ortley, Rhode Island Greening, Rome Beauty, Tompkins King (sometimes watercores badly), and Wagener.

*Districts 6 and 7.*—Esopus and Yellow Newtown are the most important; Jonathan (in district 6) and Jonathan and Winesap (in district 7) also occur to some extent.

The percentage of each of the different varieties in the normal commercial crop for the entire State is indicated in connection with Table III.

### CALIFORNIA.

*Distribution.*—Apple growing in California is widely distributed. From 100 to 500 acres or more of bearing trees occur in nearly every county in the State, but a very large proportion of the commercial crop is produced in two or three sections. The Pajaro Valley, which includes the southern part of Santa Cruz County and the northern part of Monterey County, perhaps more commonly called the Watsonville district, is the most important apple-growing section in California, the two counties named producing nearly 65 per cent of the entire crop of the State. The Sebastopol section of Sonoma County is the second largest district, that county producing about 16 per cent of the normal crop of the State. The other counties, each of which produces 2 per cent[2] or more of the normal crop of the entire State, are San Bernardino (4 per cent), Nevada (3 per cent), and Los Angeles and Humboldt (each 2 per cent). The production in each of the counties not named in the present connection is less than 2 per cent of a normal crop of the State. Recent plantings in San Diego, San Bernardino, and Riverside Counties doubtless will increase materially the apple production in these counties within the next few years.

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[1] Lewis, C. I. Orchard management. Oreg. Agr. Exp. Sta. Bul. 111, 96 p., 41 fig. 1911.

[2] Estimates of the Office of the California State Commissioner of Horticulture.

*Varieties.*—A large proportion of the commercial apple crop of California is made up of three varieties, Yellow Bellflower and Yellow Newtown, grown in the Pajaro Valley, and the Gravenstein, which characterizes the output from the Sebastopol section of Sonoma County.

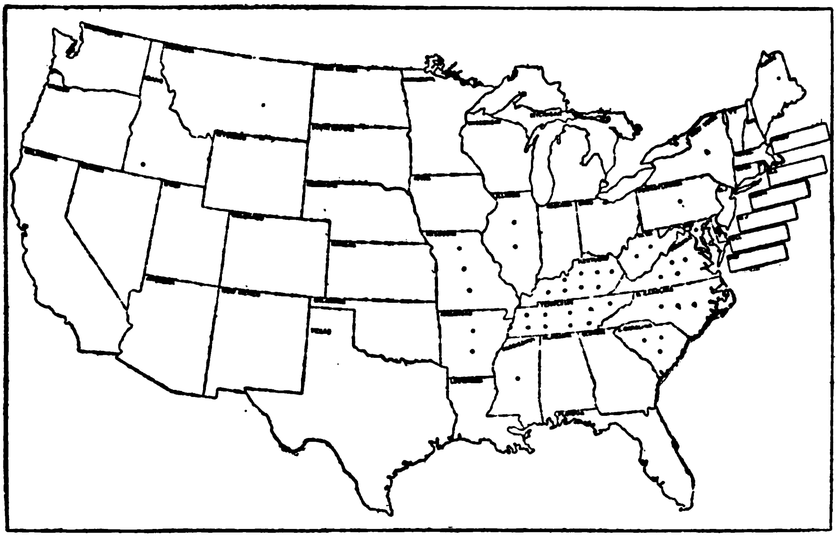

FIG. 12.—Outline map of the United States, showing the distribution by States of that portion of the estimated average apple crop for the years 1909 to 1913, inclusive, which is harvested in June. Each dot represents 30,000 bushels. The arrangement of the dots within the State boundaries has no significance.

Perhaps no more comprehensive index of the regional value of varieties can be given than the summary of the responses made by apple growers to a request issued by the Office of the California State Commissioner of Horticulture for information in regard to what were the leading sorts, which is substantially as follows:

It is interesting to note in connection with first choice of varieties in answer to question No. 12 [Name your leading varieties in the order of their impor-

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[1] Weldon, George P. Apple growing in California . . . p. 124 [Sacramento], 1914. Issued by the California State Commission of Horticulture.

tance] that one man, reporting from Butte County, places Black Ben first. Four reporting from El Dorado (no two agreeing) gave Rome Beauty, Esopus, Baldwin, and Sutton. One man from Fresno reports Fameuse as his first choice. Humboldt County is represented by six growers, giving Wagener, Tompkins King, Esopus, and Yellow Bellflower; two favored Rhode Island Greening. Two reports from Madera County were received, both giving White Pearmain as the leading variety for that section. In Mendocino County the following varieties are said to be the best by four who answered the questions: Jonathan, Swaar, Tompkins King, and Baldwin. One report from Monterey County places the Yellow Newtown first. Eleven orchardists reported from Riverside County, giving a leading place to the following: King David, Esopus, Rhode Island Greening; three favored Rome Beauty and five Delicious. Eight orchardists were heard from in San Bernardino County, one giving the Jonathan first place, two Winesap, and five Rome Beauty. From San Diego County nine reports came, one giving Jonathan as the leading variety, one Julian Duchess, one Paragon, three Yellow Newtown, and three Yellow Bellflower. As would naturally be expected, only two varieties were given first place by nine of the leading orchardists reporting from Santa Cruz County; six favored the Yellow Newtown and three the Yellow Bellflower.

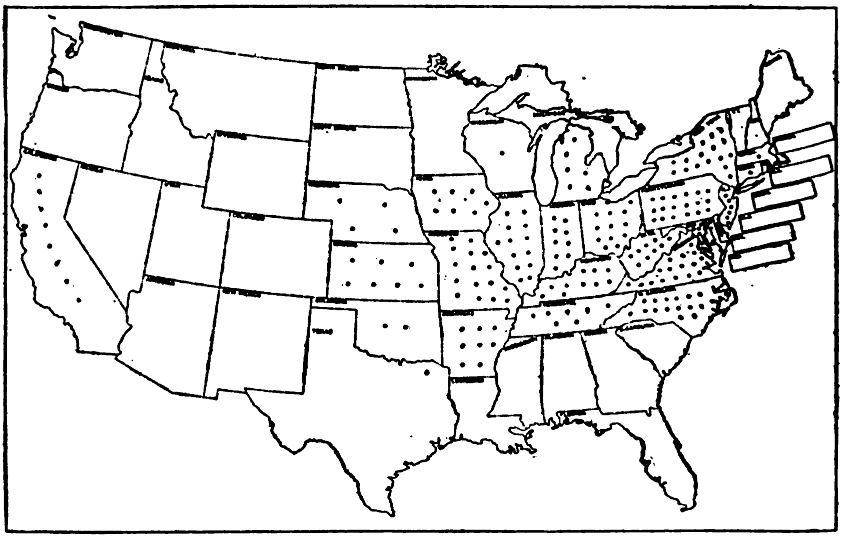

FIG. 13.—Outline map of the United States, showing the distribution by States of that portion of the estimated average apple crop for the years 1909 to 1913, inclusive, which is harvested in July. Each dot represents 30,000 bushels. The arrangement of the dots within the State boundaries has no significance.

The second county in importance from the standpoint of production, viz, Sonoma, is represented in these answers by eleven growers, eight of whom favor the Gravenstein, one the Alexander, one the Rome Beauty, and one the Yellow Newtown. One report from Tehama County gives the Yellow Newtown first place.

The replies to the above-mentioned request for lists of the leading sorts in the different sections mentioned in all some 48 different varieties, of which the following 20, listed alphabetically, are given prominence in the bulletin already cited, because of their relative importance in the apple industry of the State:

**Arkansas** (*Mammoth Black Twig*).—Grown only to a limited extent, but has some very desirable characteristics.

**Arkansas Black.**—Rather popular in some parts of southern California.

**Baldwin.**—Does quite well in a few favored localities in the mountains. Quite a large acreage has been planted in Sonoma County.

**Banana** (*Winter Banana*).—Usually does best at rather high altitudes, though excellent specimens have been grown in Santa Cruz County.

**Black Ben.**—This variety, or Gano, is suggested for planting instead of Ben Davis, which at present constitutes nearly 4 per cent of the entire crop of the State.

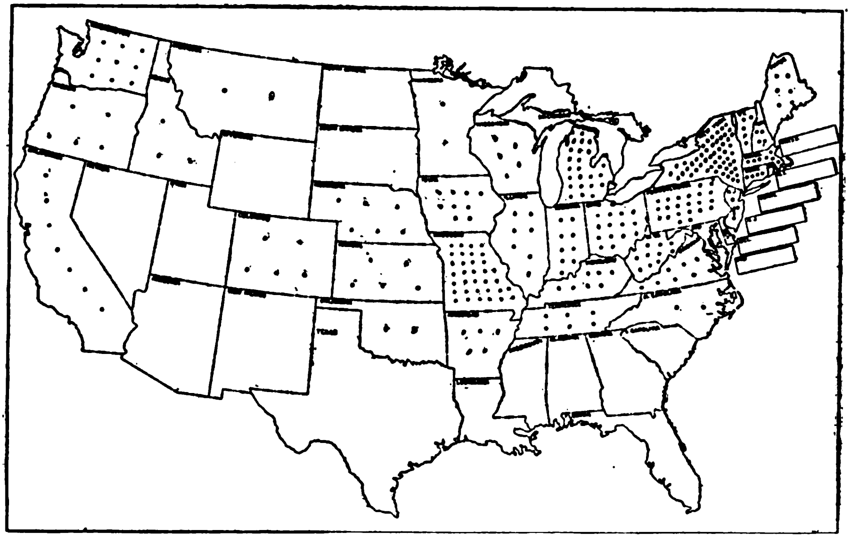

Fig. 14.—Outline map of the United States, showing the distribution by States of that portion of the estimated average apple crop for the years 1909 to 1913, inclusive, which is harvested in August. Each dot represents 30,000 bushels. The arrangement of the dots within the State boundaries has no significance.

**Delicious.**—Not yet fully tested, but considered promising in certain parts of the foothills and mountainous sections of southern California.

**Esopus.**—Not generally grown, but recommended by some for a few localities.

**Gravenstein.**—Does well in many parts of the State, but is of special importance in the Sebastopol section.

**Grimes.**—Occurs only occasionally, but as a rule it gives good results wherever grown.

**Jonathan.**—Not generally grown, but reported to do well in places in Riverside, San Bernardino, San Diego, El Dorado, Mendocino, and Humboldt Counties.

**King David.**—Not fully tested, but considerably planted in some of the younger orchards in Riverside and San Bernardino Counties.

*Mammoth Black Twig.*—See **Arkansas.**

ORTLEY—Especially mentioned for the foothill sections in Placer and Mariposa Counties.

RHODE ISLAND GREENING.—Especially mentioned for Humboldt and San Diego Counties—the extreme northern and southern parts of the State.

ROME BEAUTY.—Planted more or less widely. Reported to do especially well in the Yucaipa section of San Bernardino County.

*Spitzenberg.*—See ESOPUS.

STAYMAN WINESAP.—Not yet extensively grown, but considered very promising for the apple sections of San Bernardino, Riverside, and Tehama Counties.

WAGENER.—Reported to do well in sections of Humboldt, Mendocino, Sonoma, and Napa Counties.

WHITE PEARMAIN (*Winter Pearmain*).—Occurs quite generally in the older orchards in many parts of the State where it habitually does well. It is especially mentioned for the mountainous sections of Madera, San Bernardino, and San Diego Counties; also does well in the Pajaro and Santa Clara Valleys.

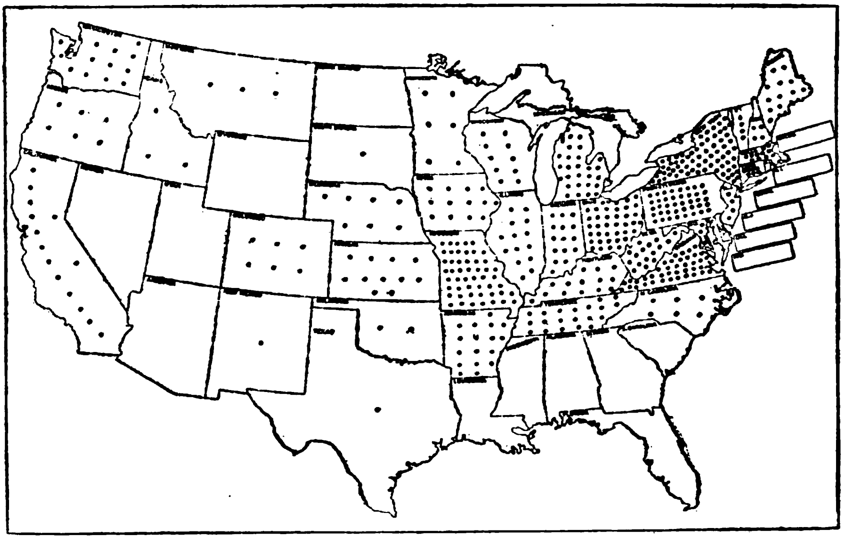

FIG. 15.—Outline map of the United States, showing the distribution by States of that portion of the estimated average apple crop for the years 1909 to 1918, inclusive, which is harvested in September. Each dot represents 30,000 bushels. The arrangement of the dots within the State boundaries has no significance.

WINESAP.—Quite extensively planted in the foothills; it is widely distributed in the older orchards in many sections of the State.

*Winter Banana.*—See BANANA.

YELLOW BELLFLOWER.—Of special value in the Watsonville district where, with the Yellow Newtown, it very largely forms the basis of the apple industry of that section, but is planted more or less widely in many parts of the State.

YELLOW NEWTOWN.—The comments under the preceding variety also apply to the Yellow Newtown. Aside from the Watsonville section, it is also especially mentioned for planting in Humboldt and Lassen Counties in the northern part and in San Diego, Riverside, and San Bernardino Counties in the southern part of the State.

## ESTIMATED RELATIVE PROPORTION OF EARLY AND LATE APPLES IN DIFFERENT STATES.

The proportionate quantity of early and late varieties in the different States and the millions of barrels of each in 1915 are shown in figure 11. The designations early and late are based on varieties, those which have normally a short period of use being grouped as early and the varieties that are commonly stored or possess naturally long-keeping quality as late. The numerals shown on the map in figure 11 are listed in Table V.

The accompanying maps, designated as figures 12, 13, 14, 15, and 16, indicate the estimated quantity of apples in the average crops for 1909 to 1913 inclusive, harvested, respectively, in June, July, August, September, and October, figure 16 showing also the fruit picked later than October. In a general way, these maps also indicate geographically the sections of country from which the crop is ready for consumption or market in the several months covered by the harvest period. It should be stated in this connection that the data which form the basis of these maps are not entirely comprehensive, but it is believed that this regional distribution of the harvesting of apples in the different months shown by these maps is suggestive as well as instructive.

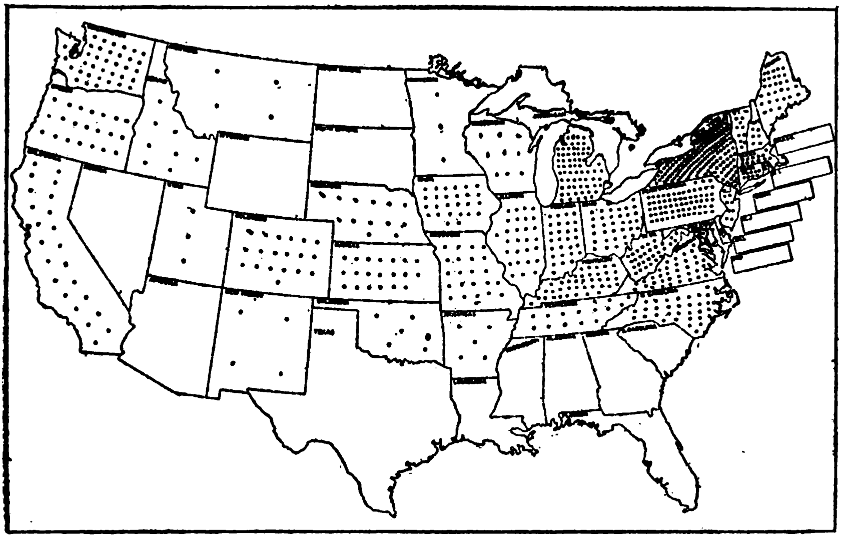

FIG. 16.—Outline map of the United States, showing the distribution by States of that portion of the estimated average apple crop for the years 1909 to 1913, inclusive, which is harvested in October and later. Each dot represents 30,000 bushels. The arrangement of the dots within the State boundaries has no significance.

TABLE V.—*Estimated production (in barrels) of early and of late varieties of apples in the United States, 1915.*

| Divisions and States. | Early varieties. | Late varieties. | Total. |
|---|---|---|---|
| New England States: | | | |
| Maine | 202,000 | 518,000 | 720,000 |
| New Hampshire | 74,000 | 279,000 | 353,000 |
| Vermont | 97,000 | 227,000 | 324,000 |
| Massachusetts | 204,000 | 681,000 | 885,000 |
| Rhode Island | 15,000 | 44,000 | 59,000 |
| Connecticut | 107,000 | 404,000 | 511,000 |
| Middle Atlantic States: | | | |
| New York | 2,132,000 | 6,396,000 | 8,528,000 |
| New Jersey | 326,000 | 451,000 | 777,000 |
| Pennsylvania | 1,525,000 | 3,560,000 | 5,085,000 |
| South Atlantic States: | | | |
| Delaware | 57,000 | 65,000 | 122,000 |
| Maryland | 264,000 | 536,000 | 800,000 |
| Virginia | 1,494,000 | 2,899,000 | 4,393,000 |
| West Virginia | 854,000 | 1,659,000 | 2,513,000 |
| North Carolina | 1,085,000 | 887,000 | 1,972,000 |
| South Carolina | 155,000 | 66,000 | 221,000 |
| Georgia | 313,000 | 312,000 | 625,000 |
| Florida | ........ | ........ | ........ |
| East North-Central States: | | | |
| Ohio | 1,915,000 | 4,069,000 | 5,984,000 |
| Indiana | 1,320,000 | 2,563,000 | 3,883,000 |
| Illinois | 1,651,000 | 3,065,000 | 4,716,000 |
| Michigan | 1,039,000 | 2,111,000 | 3,150,000 |
| Wisconsin | 884,000 | 589,000 | 1,473,000 |
| West North-Central States: | | | |
| Minnesota | 272,000 | 140,000 | 412,000 |
| Iowa | 1,707,000 | 1,513,000 | 3,220,000 |
| Missouri | 1,760,000 | 4,527,000 | 6,287,000 |
| North Dakota | ........ | ........ | ........ |
| South Dakota | 73,000 | 27,000 | 100,000 |
| Nebraska | 507,000 | 760,000 | 1,267,000 |
| Kansas | 637,000 | 1,488,000 | 2,125,000 |
| East South-Central States: | | | |
| Kentucky | 1,668,000 | 2,502,000 | 4,170,000 |
| Tennessee | 1,012,000 | 1,013,000 | 2,025,000 |
| Alabama | 319,000 | 213,000 | 532,000 |
| Mississippi | 99,000 | 42,000 | 141,000 |
| West South-Central States: | | | |
| Louisiana | ........ | ........ | ........ |
| Texas | 56,000 | 131,000 | 187,000 |
| Oklahoma | 242,000 | 538,000 | 780,000 |
| Arkansas | 296,000 | 887,000 | 1,183,000 |
| Mountain States: | | | |
| Montana | 121,000 | 226,000 | 347,000 |
| Wyoming | ........ | ........ | ........ |
| Colorado | 118,000 | 575,000 | 693,000 |
| New Mexico | 49,000 | 224,000 | 273,000 |
| Arizona | 12,000 | 28,000 | 40,000 |
| Utah | 35,000 | 107,000 | 142,000 |
| Nevada | 12,000 | 28,000 | 40,000 |
| Idaho | 86,000 | 487,000 | 573,000 |
| Pacific States: | | | |
| Washington | 608,000 | 1,825,000 | 2,433,000 |
| Oregon | 303,000 | 740,000 | 1,043,000 |
| California | 625,000 | 938,000 | 1,563,000 |
| United States | 26,330,000 | 50,340,000 | 76,670,000 |

## ESTIMATED ANNUAL PRODUCTION, 1890 TO 1916.

The estimated total annual production of apples for the entire country from 1890 to 1916, inclusive, based on the Eleventh (1889), Twelfth (1900), and the Thirteenth (1910) Census reports, and upon reports from correspondents of the Bureau of Crop Estimates, is given in Table VI.

**TABLE VI.**—*Estimated annual production (in barrels) of apples in the United States, 1890 to 1916, inclusive.*[1]

[In thousands; i. e., 000 omitted.]

| Divisions and States. | 1889 census. | 1890 | 1891 | 1892 | 1893 | 1894 | 1895 | 1896 | 1897 | 1898 |
|---|---|---|---|---|---|---|---|---|---|---|
| **North Atlantic States:** | | | | | | | | | | |
| Maine | 1,024 | 675 | 1,230 | 1,245 | 525 | 1,485 | 480 | 1,830 | 225 | 735 |
| New Hampshire | 761 | 507 | 1,187 | 1,231 | 502 | 1,410 | 434 | 1,904 | 467 | 1,425 |
| Vermont | 404 | 408 | 793 | 725 | 594 | 874 | 532 | 1,003 | 484 | 656 |
| Massachusetts | 563 | 342 | 1,190 | 1,150 | 680 | 1,833 | 846 | 2,541 | 680 | 1,200 |
| Rhode Island | 80 | 23 | 118 | 82 | 61 | 93 | 80 | 147 | 38 | 63 |
| Connecticut | 665 | 222 | 1,209 | 752 | 725 | 1,089 | 1,312 | 1,500 | 753 | 1,063 |
| New York | 2,831 | 2,687 | 9,803 | 8,149 | 5,713 | 8,172 | 8,493 | 18,059 | 6,557 | 4,385 |
| New Jersey | 201 | 170 | 957 | 615 | 747 | 798 | 1,322 | 792 | 762 | 440 |
| Pennsylvania | 2,518 | 1,017 | 6,930 | 4,492 | 4,730 | 4,715 | 5,225 | 8,841 | 4,680 | 4,875 |
| Total | 9,017 | 6,051 | 23,417 | 18,441 | 14,276 | 20,469 | 18,724 | 36,616 | 14,645 | 14,842 |
| **South Atlantic States:** | | | | | | | | | | |
| Delaware | 37 | 25 | 153 | 34 | 112 | 30 | 206 | 42 | 100 | 40 |
| Maryland | 471 | 245 | 983 | 306 | 816 | 198 | 923 | 224 | 791 | 402 |
| Virginia | 2,797 | 1,419 | 4,213 | 1,812 | 4,213 | 850 | 4,860 | 1,393 | 4,667 | 1,890 |
| West Virginia | 1,480 | 374 | 2,415 | 1,027 | 1,260 | 404 | 3,013 | 1,710 | 2,218 | 720 |
| North Carolina | 2,531 | 1,280 | 2,400 | 1,890 | 2,457 | 532 | 3,530 | 1,353 | 2,517 | 2,728 |
| South Carolina | 145 | 93 | 150 | 147 | 152 | 34 | 159 | 86 | 143 | 134 |
| Georgia | 704 | 303 | 506 | 530 | 383 | 138 | 545 | 255 | 367 | 273 |
| Florida | 1 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Total | 8,165 | 3,739 | 10,820 | 5,746 | 9,393 | 2,186 | 13,236 | 5,063 | 10,802 | 6,186 |
| **East North-Central States:** | | | | | | | | | | |
| Ohio | 4,596 | 1,300 | 5,219 | 262 | 963 | 3,597 | 8,239 | 6,593 | 2,552 | 1,420 |
| Indiana | 2,928 | 1,111 | 3,198 | 889 | 393 | 1,350 | 4,263 | 2,603 | 1,947 | 500 |
| Illinois | 3,200 | 1,386 | 2,882 | 880 | 483 | 2,128 | 3,897 | 3,717 | 4,674 | 1,239 |
| Michigan | 4,385 | 2,639 | 2,788 | 2,733 | 2,403 | 4,347 | 1,803 | 7,663 | 1,260 | 3,939 |
| Wisconsin | 531 | 354 | 403 | 356 | 274 | 375 | 146 | 508 | 155 | 474 |
| Total | 15,640 | 6,790 | 14,490 | 5,120 | 4,516 | 11,797 | 18,347 | 21,085 | 10,588 | 7,572 |
| **West North-Central States:** | | | | | | | | | | |
| Minnesota | 27 | 33 | 35 | 40 | 39 | 41 | 34 | 74 | 51 | 89 |
| Iowa | 1,680 | 1,265 | 1,856 | 1,017 | 640 | 1,452 | 1,283 | 2,239 | 1,849 | 922 |
| Missouri | 2,899 | 2,420 | 3,220 | 1,381 | 936 | 2,569 | 4,816 | 3,780 | 3,509 | 784 |
| North Dakota | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| South Dakota | 1 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Nebraska | 391 | 283 | 567 | 194 | 254 | 355 | 576 | 686 | 837 | 428 |
| Kansas | 1,238 | 1,200 | 2,080 | 583 | 475 | 1,760 | 1,757 | 1,530 | 1,615 | 667 |
| Total | 6,235 | 5,201 | 7,758 | 3,215 | 2,345 | 6,177 | 8,466 | 8,309 | 7,862 | 2,889 |
| **South-Central States:** | | | | | | | | | | |
| Kentucky | 3,560 | 1,125 | 3,634 | 2,350 | 1,440 | 588 | 5,400 | 2,091 | 2,444 | 1,696 |
| Tennessee | 2,428 | 1,606 | 2,743 | 2,283 | 2,731 | 657 | 4,020 | 1,875 | 2,679 | 1,402 |
| Alabama | 413 | 212 | 353 | 462 | 313 | 181 | 501 | 159 | 389 | 386 |
| Mississippi | 202 | 50 | 152 | 161 | 129 | 96 | 199 | 151 | 132 | 120 |
| Louisiana | 30 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Texas | 248 | 90 | 253 | 183 | 203 | 187 | 287 | 248 | 287 | 260 |
| Oklahoma | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 33 | 83 | 53 |
| Arkansas | 631 | 528 | 910 | 767 | 901 | 539 | 1,674 | 759 | 1,507 | 970 |
| Total | 7,521 | 3,611 | 8,045 | 6,206 | 5,716 | 2,247 | 12,082 | 4,816 | 7,522 | 4,887 |
| **Far Western States:** | | | | | | | | | | |
| Montana | 2 | ...... | ...... | ...... | 7 | 17 | 13 | 18 | 20 | 27 |
| Wyoming | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Colorado | 24 | 25 | 45 | 47 | 33 | 99 | 114 | 83 | 141 | 113 |
| New Mexico | 12 | 13 | 27 | 27 | 30 | 33 | 50 | 33 | 83 | 58 |
| Arizona | 1 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Utah | 19 | 27 | 67 | 58 | 67 | 59 | 96 | 57 | 143 | 110 |
| Nevada | 10 | 10 | 10 | 7 | 3 | 7 | 7 | 7 | 7 | 7 |
| Idaho | 29 | 40 | 57 | 50 | 83 | 90 | 103 | 117 | 80 | 133 |
| Washington | 98 | 174 | 231 | 204 | 274 | 273 | 382 | 324 | 567 | 686 |
| Oregon | 346 | 448 | 540 | 368 | 544 | 527 | 569 | 238 | 747 | 742 |
| California | 552 | 585 | 797 | 690 | 970 | 902 | 1,011 | 768 | 1,370 | 1,100 |
| Total | 1,093 | 1,322 | 1,772 | 1,450 | 2,011 | 2,007 | 2,346 | 1,644 | 3,158 | 2,977 |
| Grand total | 47,702 | 26,714 | 66,302 | 40,179 | 38,258 | 44,883 | 73,200 | 77,533 | 54,576 | 39,354 |

[1] Monthly Crop Report, vol. 2, no. 10 (October, 1916), p. 103.

TABLE VI.—*Estimated annual production (in barrels) of apples, etc.*—Contd.

| Divisions and States. | 1899 census. | 1900 | 1901 | 1902 | 1903 | 1904 | 1905 | 1906 | 1907 | 1908 |
|---|---|---|---|---|---|---|---|---|---|---|
| North Atlantic States: | | | | | | | | | | |
| Maine | 474 | 1,667 | 850 | 1,280 | 1,390 | 1,867 | 933 | 1,267 | 1,650 | 600 |
| New Hampshire | 660 | 1,900 | 333 | 1,433 | 533 | 1,567 | 500 | 667 | 700 | 500 |
| Vermont | 392 | 1,267 | 567 | 1,000 | 517 | 1,300 | 567 | 733 | 700 | 733 |
| Massachusetts | 1,008 | 2,100 | 567 | 2,133 | 1,100 | 1,833 | 900 | 1,133 | 967 | 800 |
| Rhode Island | 113 | 133 | 33 | 167 | 67 | 100 | 100 | 100 | 67 | 67 |
| Connecticut | 1,236 | 1,267 | 367 | 1,567 | 667 | 967 | 800 | 833 | 733 | 333 |
| New York | 8,037 | 15,667 | 3,667 | 13,667 | 15,333 | 18,333 | 7,000 | 10,333 | 9,333 | 11,000 |
| New Jersey | 1,547 | 967 | 333 | 1,333 | 1,033 | 1,033 | 867 | 700 | 733 | 433 |
| Pennsylvania | 8,020 | 6,000 | 3,000 | 6,333 | 6,167 | 8,333 | 4,500 | 5,833 | 4,600 | 4,933 |
| Total | 21,487 | 30,967 | 9,717 | 28,898 | 26,807 | 35,333 | 16,167 | 21,600 | 19,483 | 19,400 |
| South Atlantic States: | | | | | | | | | | |
| Delaware | 231 | 200 | 33 | 200 | 100 | 167 | 167 | 133 | 67 | 100 |
| Maryland | 1,050 | 900 | 633 | 667 | 900 | 700 | 933 | 667 | 667 | 733 |
| Virginia | 3,279 | 2,833 | 3,167 | 2,233 | 4,367 | 2,000 | 3,367 | 1,833 | 1,733 | 2,967 |
| West Virginia | 2,499 | 1,400 | 2,033 | 1,433 | 1,267 | 2,167 | 1,600 | 1,967 | 900 | 1,767 |
| North Carolina | 1,554 | 2,467 | 2,167 | 2,200 | 2,067 | 2,200 | 1,667 | 1,567 | 867 | 2,367 |
| South Carolina | 84 | 127 | 120 | 143 | 147 | 163 | 120 | 160 | 58 | 253 |
| Georgia | 224 | 300 | 233 | 333 | 367 | 400 | 233 | 433 | 167 | 500 |
| Florida | 1 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| Total | 8,925 | 8,227 | 8,387 | 7,210 | 9,213 | 7,797 | 8,087 | 6,760 | 4,453 | 8,687 |
| East North-Central States: | | | | | | | | | | |
| Ohio | 6,872 | 4,600 | 3,500 | 4,233 | 4,500 | 4,667 | 1,600 | 5,333 | 1,333 | 2,000 |
| Indiana | 2,873 | 1,500 | 2,167 | 2,100 | 1,933 | 1,967 | 1,367 | 3,000 | 667 | 733 |
| Illinois | 3,059 | 2,500 | 1,967 | 3,367 | 1,700 | 2,000 | 1,500 | 4,033 | 533 | 867 |
| Michigan | 2,977 | 3,933 | 1,733 | 6,000 | 5,133 | 6,233 | 2,100 | 4,567 | 3,167 | 2,333 |
| Wisconsin | 101 | 500 | 200 | 600 | 467 | 800 | 433 | 733 | 567 | 533 |
| Total | 15,883 | 13,033 | 9,567 | 16,300 | 13,733 | 15,667 | 7,000 | 17,667 | 6,267 | 6,467 |
| West North-Central States: | | | | | | | | | | |
| Minnesota | 40 | 133 | 83 | 133 | 200 | 217 | 233 | 200 | 300 | 167 |
| Iowa | 1,043 | 1,767 | 967 | 2,233 | 1,600 | 2,333 | 1,267 | 2,633 | 1,200 | 1,000 |
| Missouri | 2,165 | 2,767 | 3,500 | 3,900 | 2,067 | 3,233 | 2,100 | 6,667 | 433 | 2,033 |
| North Dakota | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| South Dakota | 6 | 13 | 17 | 20 | 33 | 47 | 40 | 57 | 50 | 30 |
| Nebraska | 448 | 600 | 567 | 1,033 | 467 | 933 | 533 | 1,300 | 300 | 600 |
| Kansas | 1,071 | 1,767 | 2,267 | 1,933 | 1,000 | 1,533 | 1,200 | 2,567 | 60 | 1,900 |
| Total | 4,774 | 7,047 | 7,400 | 9,253 | 5,367 | 8,297 | 5,373 | 13,423 | 2,343 | 5,730 |
| South-Central States: | | | | | | | | | | |
| Kentucky | 2,018 | 2,133 | 2,767 | 1,567 | 2,367 | 2,333 | 1,900 | 3,033 | 1,000 | 1,333 |
| Tennessee | 1,796 | 2,167 | 2,433 | 1,533 | 2,133 | 1,767 | 1,133 | 2,367 | 533 | 1,800 |
| Alabama | 240 | 400 | 367 | 367 | 467 | 500 | 267 | 467 | 133 | 433 |
| Mississippi | 83 | 167 | 133 | 137 | 167 | 143 | 107 | 127 | 47 | 150 |
| Louisiana | 23 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| Texas | 197 | 267 | 167 | 200 | 167 | 200 | 233 | 167 | 100 | 133 |
| Oklahoma | 111 | 157 | 147 | 217 | 193 | 183 | 250 | 367 | 317 | 233 |
| Arkansas | 937 | 967 | 1,100 | 1,333 | 800 | 1,333 | 1,067 | 1,433 | 1,200 | 533 |
| Total | 5,405 | 6,257 | 7,113 | 5,353 | 6,293 | 6,460 | 4,957 | 7,960 | 3,330 | 4,617 |
| Far Western States: | | | | | | | | | | |
| Montana | 15 | 33 | 27 | 60 | 73 | 87 | 103 | 120 | 147 | 170 |
| Wyoming | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | 3 |
| Colorado | 86 | 200 | 243 | 400 | 333 | 667 | 533 | 733 | 133 | 467 |
| New Mexico | 47 | 87 | 73 | 117 | 67 | 103 | 140 | 157 | 40 | 160 |
| Arizona | 4 | 3 | 7 | 7 | 3 | 7 | 17 | 13 | 13 | 23 |
| Utah | 63 | 133 | 83 | 109 | 127 | 157 | 140 | 143 | 73 | 127 |
| Nevada | 4 | 7 | 10 | 13 | 20 | 20 | 23 | 27 | 37 | 10 |
| Idaho | 75 | 167 | 83 | 170 | 157 | 217 | 167 | 203 | 233 | 253 |
| Washington | 243 | 650 | 623 | 767 | 867 | 900 | 833 | 1,000 | 1,267 | 1,067 |
| Oregon | 291 | 767 | 500 | 733 | 800 | 867 | 600 | 900 | 700 | 867 |
| California | 1,163 | 1,067 | 1,333 | 1,400 | 1,367 | 1,300 | 1,267 | 1,533 | 1,333 | 1,600 |
| Total | 1,991 | 3,113 | 2,983 | 3,767 | 3,813 | 4,323 | 3,823 | 4,830 | 3,977 | 4,747 |
| Grand total | 58,466 | 68,643 | 45,167 | 70,777 | 65,227 | 77,877 | 45,407 | 72,240 | 39,853 | 49,647 |

TABLE VI.—*Estimated annual production (in barrels) of apples, etc.*—Contd.

| Divisions and States. | 1909 census. | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | 1916 |
|---|---|---|---|---|---|---|---|---|
| **North Atlantic States:** | | | | | | | | |
| Maine | 1,212 | 1,183 | 2,267 | 1,800 | 1,000 | 2,467 | 720 | 1,680 |
| New Hampshire | 369 | 600 | 533 | 733 | 267 | 667 | 353 | 532 |
| Vermont | 487 | 900 | 750 | 867 | 233 | 1,067 | 324 | 1,104 |
| Massachusetts | 850 | 967 | 1,000 | 1,100 | 767 | 1,467 | 885 | 1,150 |
| Rhode Island | 71 | 100 | 133 | 100 | 100 | 133 | 59 | 87 |
| Connecticut | 514 | 600 | 800 | 567 | 700 | 833 | 511 | 610 |
| New York | 8,470 | 5,667 | 13,000 | 14,667 | 6,500 | 16,533 | 8,528 | 12,600 |
| New Jersey | 469 | 567 | 1,033 | 567 | 700 | 1,133 | 777 | 750 |
| Pennsylvania | 3,683 | 3,867 | 6,833 | 4,233 | 3,400 | 7,700 | 5,085 | 6,207 |
| **Total** | 16,124 | 14,450 | 26,350 | 24,633 | 13,667 | 32,000 | 17,242 | 24,720 |
| **South Atlantic States:** | | | | | | | | |
| Delaware | 61 | 117 | 100 | 140 | 60 | 167 | 122 | 83 |
| Maryland | 608 | 900 | 867 | 883 | 433 | 1,167 | 800 | 848 |
| Virginia | 2,036 | 4,033 | 2,400 | 5,000 | 1,733 | 5,100 | 4,392 | 4,433 |
| West Virginia | 1,408 | 2,367 | 2,600 | 3,433 | 333 | 4,133 | 2,513 | 3,344 |
| North Carolina | 1,592 | 2,400 | 1,200 | 2,533 | 1,000 | 3,000 | 1,972 | 2,358 |
| South Carolina | 121 | 247 | 157 | 200 | 87 | 267 | 221 | 196 |
| Georgia | 299 | 467 | 267 | 467 | 300 | 667 | 625 | 541 |
| Florida | 1 | ....... | ....... | ....... | ....... | ....... | ....... | ....... |
| Total | 6,125 | 10,530 | 7,590 | 12,657 | 3,947 | 14,500 | 10,645 | 11,803 |
| **East North-Central States:** | | | | | | | | |
| Ohio | 1,555 | 1,967 | 6,233 | 3,533 | 1,600 | 4,433 | 5,984 | 2,867 |
| Indiana | 920 | 1,633 | 2,967 | 1,400 | 2,200 | 1,433 | 3,883 | 1,307 |
| Illinois | 1,031 | 267 | 3,533 | 1,933 | 2,733 | 1,233 | 4,716 | 1,616 |
| Michigan | 4,111 | 1,400 | 4,100 | 5,733 | 2,967 | 5,733 | 3,150 | 4,160 |
| Wisconsin | 744 | 133 | 1,000 | 667 | 1,333 | 733 | 1,473 | 878 |
| Total | 8,360 | 5,400 | 17,833 | 13,267 | 10,833 | 13,567 | 19,205 | 10,828 |
| **West North-Central States:** | | | | | | | | |
| Minnesota | 348 | 50 | 433 | 233 | 600 | 233 | 412 | 422 |
| Iowa | 2,249 | 67 | 3,167 | 500 | 2,367 | 533 | 3,220 | 1,575 |
| Missouri | 3,323 | 2,533 | 3,867 | 6,400 | 2,633 | 4,167 | 6,287 | 2,700 |
| North Dakota | 1 | ....... | ....... | ....... | ....... | ....... | ....... | ....... |
| South Dakota | 64 | 10 | 80 | 67 | 107 | 67 | 100 | 116 |
| Nebraska | 1,107 | 467 | 1,200 | 933 | 767 | 400 | 1,267 | 567 |
| Kansas | 452 | 2,200 | 800 | 2,233 | 900 | 1,033 | 2,125 | 1,040 |
| Total | 7,544 | 5,327 | 9,547 | 10,367 | 7,373 | 6,433 | 13,410 | 6,420 |
| **South-Central States:** | | | | | | | | |
| Kentucky | 2,456 | 1,767 | 2,033 | 3,200 | 2,300 | 3,000 | 4,170 | 2,147 |
| Tennessee | 1,547 | 1,733 | 967 | 2,967 | 1,300 | 2,867 | 2,025 | 1,772 |
| Alabama | 296 | 333 | 233 | 400 | 300 | 533 | 532 | 380 |
| Mississippi | 89 | 110 | 80 | 150 | 123 | 167 | 141 | 116 |
| Louisiana | 11 | ....... | ....... | ....... | ....... | ....... | ....... | ....... |
| Texas | 56 | 133 | 67 | 167 | 100 | 167 | 187 | 156 |
| Oklahoma | 247 | 400 | 350 | 567 | 367 | 500 | 780 | 275 |
| Arkansas | 765 | 900 | 1,000 | 1,700 | 1,333 | 1,667 | 1,183 | 1,018 |
| Total | 5,467 | 5,377 | 4,730 | 9,150 | 5,823 | 8,900 | 9,019 | 5,864 |
| **Far Western States:** | | | | | | | | |
| Montana | 189 | 140 | 300 | 300 | 280 | 300 | 347 | 256 |
| Wyoming | 6 | 3 | 7 | 10 | 10 | ....... | ....... | ....... |
| Colorado | 1,186 | 500 | 900 | 1,033 | 1,100 | 1,500 | 693 | 1,015 |
| New Mexico | 139 | 113 | 227 | 250 | 217 | 300 | 273 | 119 |
| Arizona | 24 | 33 | 37 | 43 | 30 | 32 | 40 | 46 |
| Utah | 117 | 137 | 153 | 227 | 203 | 267 | 142 | 33 |
| Nevada | 25 | 53 | 33 | 87 | 53 | 67 | 40 | 16 |
| Idaho | 220 | 417 | 400 | 550 | 467 | 567 | 573 | 147 |
| Washington | 891 | 1,933 | 1,167 | 2,567 | 2,300 | 2,767 | 2,433 | 3,225 |
| Oregon | 644 | 1,267 | 500 | 1,367 | 1,167 | 1,200 | 1,043 | 1,285 |
| California | 1,645 | 1,533 | 1,567 | 1,900 | 1,000 | 2,000 | 1,563 | 1,918 |
| Total | 5,085 | 6,130 | 5,290 | 8,333 | 6,827 | 9,000 | 7,148 | 8,060 |
| Grand total | 48,707 | 47,213 | 71,340 | 78,407 | 48,470 | 84,400 | 76,670 | 67,695 |

NOTE.—The part of this bulletin which treats of the important centers or areas of apple production and the varieties principally grown in them, from the nature of the case, must be more or less incomplete. Reference to areas of considerable commercial importance may have been omitted in some instances where conditions are such as to merit mention in the present connection. Where this has occurred it has been due to a lack of definite information concerning the importance of the areas. It is also likely that differences of opinion and experience will appear in regard to some of the lists of varieties named for the different districts.

In order that the information coming within the scope of this bulletin may be completed and made as valuable as is possible to the apple industry, the writers will appreciate any constructive suggestions that may be offered by fruit growers and others familiar with the conditions of apple production in different parts of the country.

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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 486

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ March 19, 1917

# SUGAR-CANE CULTURE FOR SIRUP PRODUCTION IN THE UNITED STATES

By

P. A. YODER, Sugar-Cane Technologist, Office of Sugar-Beet Investigations

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## INTRODUCTION.

In the preparation of this bulletin the aim has been to present a description of the practices at present in vogue among the better class of farmers engaged in the production of sugar cane in the localities where sirup is the main product of the cane. It is intended primarily for those readers who are not already familiar with the farm operations employed in sugar-cane culture and sirup making. The present bulletin will be confined mainly to the consideration of field conditions and practices and to the farm-economics phase of the industry. The subjects of insect pests and diseases of the sugar cane will be discussed only briefly, as other publications of the United States Department of Agriculture deal with these more particularly. The scope of this bulletin is not intended to cover the making and the marketing of the sirup, though some reference to these factors needs to be made in dealing with the farm-economics phase of the subject, such as the cost of the production of the cane and the sirup and the profits accruing therefrom.

Incidentally the sugar-cane industry will be considered in its relation to other farm operations, and some of the general problems arising will be noted and suggestions made as to their solution.

## GEOGRAPHIC LIMITS OF THE SUGAR-CANE INDUSTRY IN THE UNITED STATES.

Climatically, the sections of the United States which are more or less well adapted to the culture of sugar cane are the extreme southern portion of South Carolina, all of Florida, the southern third of the States of Georgia, Alabama, and Mississippi, the southern half of Louisiana, and the low coastal plains of Texas. Apparently the lower lying valleys of southwestern Arizona and southern California are adapted under irrigation to cane culture, though it has not been tried extensively in these sections.

In the portions of the country to which cane culture is restricted climatically it is further limited by its soil requirements. The crop can be grown profitably only where the soil is of the best.

Table I gives the acreage in sugar cane in the several States as shown by the census report of 1909, together with the total yields of cane and of sugar, molasses, and sirup. By molasses is understood the product from the residual liquor after removing part of the sugar. Sirup is the product made without the removal of any of the sugar.

TABLE I.—*Sugar-cane, sugar, molasses, and sirup production in the United States in 1909.*

| States. | Area in crop. | Production of cane. | Value of crop. | Farms reporting. | | Average area per farm. | Average yield of cane per acre. |
|---|---|---|---|---|---|---|---|
| | | | | Number. | Percentage of all farms. | | |
| | *Acres.* | *Tons.* | | | | *Acres.* | *Tons.* |
| United States | 476,849 | 6,240,260 | $26,415,952 | 278,233 | 4.4 | 1.7 | 13.1 |
| Alabama | 27,211 | 226,634 | 1,527,166 | 61,226 | 23.3 | .4 | 8.3 |
| Arizona | 16 | 55 | 719 | 8 | .1 | 2 | 3.4 |
| Arkansas | 3,330 | 19,868 | 152,298 | 5,286 | 2.5 | .6 | 6 |
| Florida | 12,928 | 142,517 | 1,089,698 | 19,663 | 39.3 | .7 | 11 |
| Georgia | 37,046 | 317,460 | 2,268,110 | 64,458 | 22.1 | .6 | 8.6 |
| Louisiana | 329,684 | 4,941,996 | 17,752,537 | 34,487 | 28.6 | 9.6 | 15 |
| Mississippi | 21,861 | 222,600 | 1,506,887 | 52,860 | 19.3 | .5 | 9 |
| New Mexico | 111 | 267 | 3,467 | 73 | .2 | 1.5 | 2.4 |
| North Carolina | 294 | 1,494 | 10,697 | 596 | .2 | .5 | 5.1 |
| Oklahoma | ........ | 2 | 56 | 1 | ........ | ........ | ........ |
| South Carolina | 7,053 | 59,865 | 434,634 | 19,857 | 11.3 | .4 | 8.5 |
| Texas | 34,315 | 307,502 | 1,669,683 | 19,718 | 4.7 | 1.7 | 9 |

| States. | In plantation mills, covered by the agricultural census. | | | In factories, covered by the manufacturers' census. | | |
|---|---|---|---|---|---|---|
| | Sugar. | Molasses. | Sirup. | Sugar. | Molasses. | Sirup. |
| | *Pounds.* | *Gallons.* | *Gallons.* | *Tons.* | *Gallons.* | *Gallons.* |
| United States | 125,647 | 4,153 | 21,633,579 | 326,858 | 24,587,581 | 1,449,860 |
| Alabama | 3,351 | 50 | 3,078,531 | ........ | ........ | ........ |
| Arizona | ........ | ........ | 1,040 | ........ | ........ | ........ |
| Arkansas | ........ | 130 | 286,637 | ........ | ........ | ........ |
| Florida | 47,661 | 1,339 | 2,533,096 | ........ | ........ | ........ |
| Georgia | 22,392 | 319 | 5,533,520 | ........ | ........ | ........ |
| Louisiana | 38,143 | 1,325 | 4,125,083 | 352,497 | 24,342,555 | [a] 942,997 |
| Mississippi | 1,665 | 740 | 2,920,519 | ........ | ........ | ........ |
| New Mexico | ........ | ........ | 5,088 | ........ | ........ | ........ |
| North Carolina | ........ | ........ | 21,677 | ........ | ........ | ........ |
| Oklahoma | ........ | ........ | 56 | ........ | ........ | ........ |
| South Carolina | 5,525 | 250 | 881,558 | ........ | ........ | ........ |
| Texas | 6,910 | ........ | 2,246,774 | 1,361 | 245,026 | 506,863 |

[a] The statistics from 16 factories in Louisiana making sirup from sugar cane are not included.

It will be noted from Table I that at present the production of sugar from sugar cane in the continental United States is limited exclusively to Louisiana and Texas except for small quantities made by plantation mills. In those localities where sugar is manufactured the cane industry is conducted on an extensive scale.

The sirup, on the other hand, is almost wholly made by the small farm or plantation outfits. Only a small portion of it is made by big factories, and that wholly in Louisiana and Texas. In the sirup-making section it is rare that large plantations are devoted mainly to the production of cane. The cane crop for sirup comes mostly from small fields or patches.

Half a century ago, while the price of sugar was high, certain sections of Florida were extensively engaged in cane-sugar production. During slave days large sugar plantations were operated along the Manatee River. However, the industry never revived from the shock it received during the Civil War, when nearly all the sugar houses were destroyed. (Fig. 1.) At present, while this is still an important sirup section, the cane is produced in only small areas and it is no longer the chief industry.

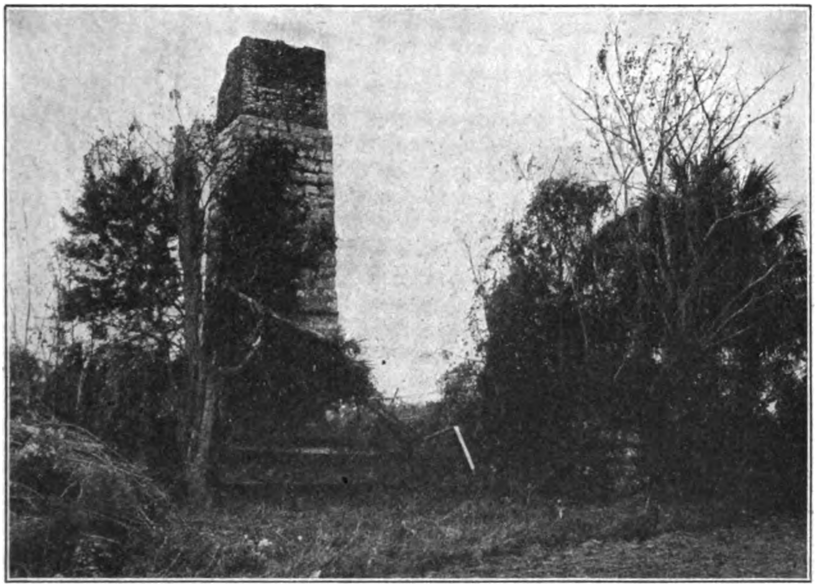

FIG. 1.—Ruins of a cane-sugar mill of antebellum days, near Manatee, Fla.

## THE NATURE OF THE SUGAR-CANE PLANT AND METHODS OF PROPAGATION.

The sugar cane (*Saccharum officinarum*) belongs to the family of grasses Graminaceæ. It is one of the largest of this family of plants, usually standing about 9 to 11 feet high before "arrowing," or going to seed, at the time it is usually harvested. (Fig. 2.) Unlike most of the grasses the seed is very small and either infertile or germinates very poorly; in fact, some of the best-known varieties do not produce fertile seed. The time required for a plant starting from a cutting to mature seed is usually from 14 to 18 months. It is very rare, therefore, in any portions of the continental United States that the cane goes to seed. Occasionally, in southern Florida and near the Gulf coast of Louisiana, after exceptionally mild winters the cane if not harvested will "arrow" and produce a flower panicle. For the foregoing reasons, and for the additional reason that seedling canes are usually of a quality very inferior to the cultivated varieties of cane, it is not practicable to propagate sugar cane commercially from seed.

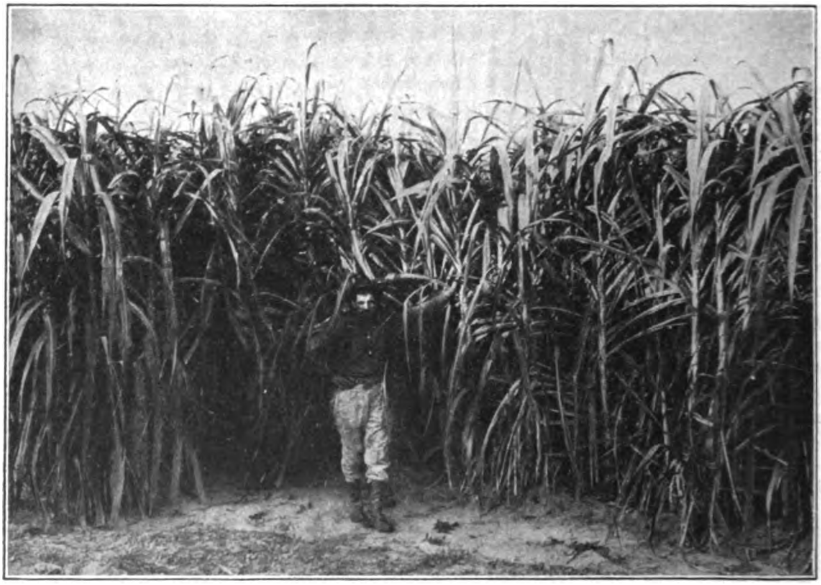

FIG. 2.—A good stand of sugar cane.

The number of inquiries which come to the Department of Agriculture concerning sugar-cane "seed" indicates that an erroneous impression is very common or that confusion exists in the minds of many persons not acquainted with the sugar cane. The confusion comes largely through a loose use of the term "cane" or even the term "sugar cane" to designate sweet sorghums used in making sirup. Some sorghum-seed and sorghum-sirup producers give their crops names suggesting sugar cane. Thus a sorghum variety is sometimes advertised as "seeded Ribbon cane," the Ribbon cane being one of the best-known varieties of sugar cane. Another sorghum variety is listed in some seed catalogues as "Japanese Honey cane." There is a Japanese cane (see under "Varieties of sugar cane") which, like ordinary sugar cane, does not produce seed in the climate of our Southern States but is used to some extent for sirup production, yielding a product practically the same as that from the ordinary cane.

The method of propagating sugar cane commercially is from cuttings, i. e., the stalk of the old plant, either the whole stalk, the stalk cut into pieces, the top part of the stalk, or the underground part, is planted. New stalks sprout from the eyes that have developed at the nodes of the stalk, and roots push out in rings around the old stalk immediately below the eyes at the nodes. On the underground part of the stalk, the so-called "root," properly called rootstock, these nodes and the eyes are especially close together and therefore relatively abundant. (See further under "Planting.") If these rootstocks of cane are not dug up, the small feeding roots connected with them die, but the rootstocks themselves remain alive and may send forth sprouts, called ratoons, from their eyes the following season and develop a new root system, thus producing another crop of cane, a so-called stubble crop or ratoon crop. However, as many of these rootstocks, because of diseases or decay, mutilation at harvesting, freezing during the winter, or other causes, do not survive, or because the soil is not in a favorable condition, the ratoon crop is rarely as good as the first or "plant-cane" crop. The second stubble or ratoon crop, if the stubble is left to grow another year, is usually still smaller. It is rare that more than three crops—the plant-cane crop and two ratoon or stubble crops—are taken from one planting, and usually it is not profitable to take more than two crops before replanting.

## VARIETIES OF SUGAR CANE.

All the varieties of sugar cane commonly used for sugar or sirup production are of the species *Saccharum officinarum.* A variety of cane known as Japanese cane and used extensively as a forage crop, but also used to some extent for sirup production, differs so widely from the ordinary sugar cane that some botanists class it as a distinct species under the name *Saccharum sinense*, probably identical with the Uba, which is favorably mentioned in Natal.

Of the innumerable varieties of sugar cane that have found favor in the various cane-producing countries, relatively few have proved well adapted to our Southern States, primarily because they are not sufficiently quick maturing. While tropical sugar-cane countries have favorable growing conditions continuously for 12 months in the year, i. e., for an unlimited period, a season of only 9 to 10 months is available near the Gulf in our Southern States to mature the crop. Farther north, where warm growing weather does not come in the spring before April and where the first frosts in the fall usually come in October or early November, sugar-cane culture can not succeed with any variety yet known. Disappointments are frequently occasioned upon introducing some high-yielding varieties from the Tropics to find that they do not show like superior qualities in the United States. As this bulletin is intended primarily for readers interested in cane culture in the continental United States, the discussion of varieties will be limited to those that have found favor in this climate.

### OLD VARIETIES.

The two varieties best known and most widely used in the Southern States are the Louisiana Purple and the Louisiana Striped. These seem to be better adapted to a wide range of soil conditions than any others of the old varieties introduced from time to time. The Louisiana Purple is also commonly called the Home Purple. In Georgia and Florida it is generally called "Red cane." It is either identical with or closely related to the Cheribon or Black Cheribon or Black Java cane of Java. The Louisiana Striped cane, also called Home Striped, outside of Louisiana is more generally called Ribbon or Red Ribbon cane. The stalks are striped with purple and green, the purple varying from a light purple or maroon to a very dark purple and the green from a light yellowish green to a dirty purplish green. This variety is presumably identical with the Striped Cheribon of Java. The Ribbon cane is commonly reported as yielding a somewhat higher tonnage than the Louisiana Purple cane mentioned above, but with a lower percentage of sugar content.

In a field of Ribbon cane, even if the seed cane was carefully selected, one can usually find numerous stalks of solid green or greenish violet and occasionally of solid purple, resulting from bud variation. The purple stalks thus originated are apparently identical with the Louisiana Purple variety just described. Conversely, cases are also reported of plain Louisiana Purple cane throwing off sports of striped cane identical with the Ribbon cane.

The green stalks coming through bud variation from Ribbon cane are commonly known in Georgia as "bastard" cane. By selecting and propagating these green variants, a strain of cane with these characteristics may be secured. Such is supposed by some to have been the origin of a variety of green cane called Crystallina in Cuba and White Cheribon in Java. It seems to be this same variety that was introduced into Louisiana from Java by P. M. La Pice in 1872, which is now being extensively grown under the name La Pice cane on some Louisiana plantations. The Ribbon cane described above is presumably identical with the variety called Transparent in parts of the West Indies, the Louisiana Purple with the Purple Transparent, and the La Pice with the White Transparent.

A variety of cane very widely grown in small garden patches, primarily as a chewing cane, generally spoken of in Georgia and northern Florida as Green cane, is apparently identical with the Otaheite of Cuba and the Bourbon of the British West Indies. Because of the soft texture of the pith, this cane is a favorite among the inhabitants for chewing. Many farmers also plant it for sirup production, as it yields a lighter colored product than the Louisiana Purple or the Red Ribbon cane. Because of its late maturity, its low yield, and its strong susceptibility to disease, however, it is not a good commercial sirup or sugar making cane. It is also a disagreeable cane to handle at harvest time because of the numerous fine prickles that cover parts of the leaves near the stem and the leaf sheaths near the midrib of the leaf.

A variety called Green Ribbon cane in Georgia and Simpson cane in some parts of Florida is practically the same as the last mentioned except in color, and it has the same advantages and disadvantages. The two are frequently grown together and one is doubtless a bud variation of the other. The color of the Green Ribbon cane is green and yellow in longitudinal stripes.

### SEEDLING VARIETIES.

While bud variation from striped varieties occurs, giving self-colored varieties, and while the opposite phenomena, viz, striped varieties coming by bud variation from self-colored varieties, have also been observed, no great success has attended experimenters in attempts to produce an improved strain of sugar cane by selection through bud variation or plant variation with respect to sugar content and purity of juice. Because of the vegetative way of propagating the cane, the plants of successive seasons are in reality but a continuation of the growth of the plants of preceding seasons. Consequently there is but little chance for variation in its economic properties. It is otherwise with plants produced from seed, whether the flowers are fertilized by chance in nature or are hand-pollinated under control. In a large number of the enterprising sugar experiment stations, work has been started in producing and testing seedling canes. In most cases the fertilizing of the flowers is left to chance, or, at most, resort is had only to planting in proximity the two varieties from which it is desired to obtain a cross, thereby increasing the chance of getting the desired cross. In a few instances the experimenters have undertaken to cross-fertilize the flowers under control, thereby producing strains with known pedigree. However, as the flowers are almost microscopic in size it is very tedious work, and as a large percentage of the progeny is unpromising or worthless, progress toward better strains by this means is very slow.

Among the immense number of seedlings that have been produced, a goodly number have already proved of economic value and are now being grown extensively on sugar plantations. A number is assigned by the originators to each of the seedlings tested, and to this number is prefixed an initial denoting the country or place in which the station is located. Thus we have the D 74 and the D 95 varieties of sugar cane, now extensively grown in Louisiana, which were originated by the Royal Agricultural Society of British Guiana, in Demerara, South America, and were introduced into Louisiana by Dr. W. C. Stubbs in 1873.

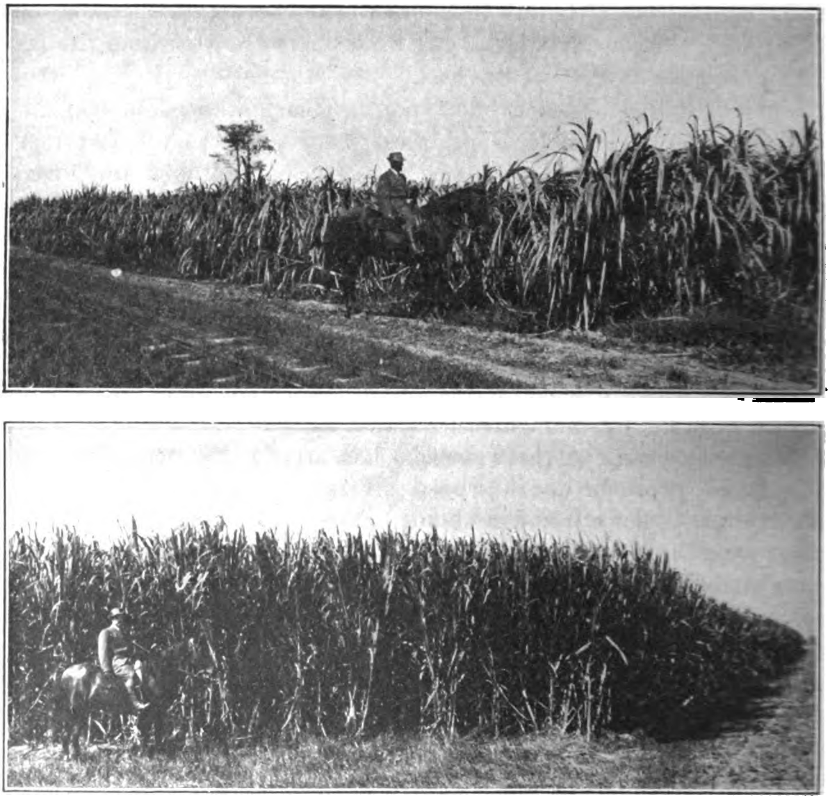

FIG. 3.—Two varieties of sugar cane (crops equally large) on the same farm after a storm: Upper, Palfrey cane, one of the old home varieties, badly lodged; lower, D 74 cane, standing erect.

Both these varieties of cane on the rich alluvial lands along the lower Mississippi and its tributary bayous generally yield both a better tonnage and a crop of higher sugar content and have the added advantage over the old home varieties of being more rigid and therefore not lodging so easily in storms, thus lessening the labor of harvesting. This erect habit of growth is especially marked in the D 74 cane. (Figs. 3 and 4.) Among the Louisiana planters these varieties have the reputation of being more sensitive to lack of fertilizer and to poor soil conditions than the Louisiana Purple and the Ribbon canes. Possibly this accounts for the fact that these varieties have not found much favor among the cane growers of Georgia and Florida, where the soil is of a lighter, more sandy character and the rainfall less abundant than in Louisiana.

The D 74 cane is a green variety which produces a sirup notably lighter in color than the Louisiana Purple and the Ribbon canes. The erect habit of growth of the plant keeps the ground from being shaded as early as with other varieties, thus necessitating (or permitting) somewhat later cultivation. As the leaves are quite stiff and the leaf sheaths do not so readily drop away from the stalk as it matures, there is slightly more trouble in stripping it at harvesting time than is experienced with other varieties. Unlike the green chewing cane previously mentioned, the D 74 cane has no prickles on the leaves and leaf sheaths.

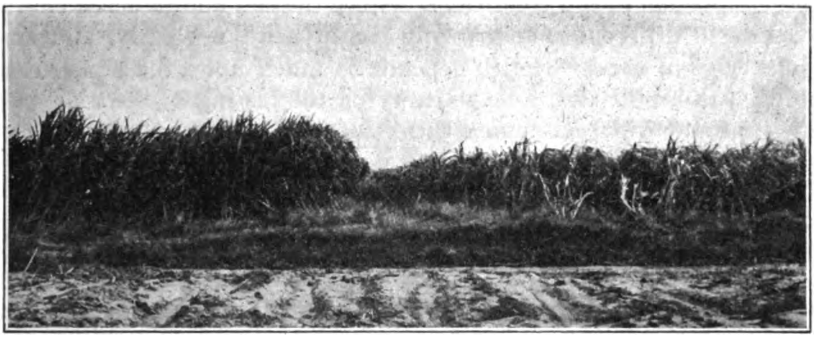

FIG. 4.—Sugar cane of the D 74 variety (at the left) and of the Louisiana Purple variety (at the right) after a storm (crops equally large).

Because of the hardness and brittleness of this variety of cane, it is not so easily milled, especially with the small farm outfits that are not provided with crushers. The D 95 cane is of a dark-purple color and can therefore not be expected to yield as light colored a sirup as the D 74 cane. It is a somewhat softer cane, however, and is therefore more easily milled. Both these Demerara varieties deserve a more thorough trial in sections where they are not now being grown.

In the fall of 1915 the writer observed in a field of D 95 can on a farm in Alabama, near Muscogee, Fla., some striped stalks. The same phenomenon has since been reported from some other fields of D 95 cane in Louisiana. We thus have another example of a bud variation in a self-colored cane (i. e., with solid color on the stalk) yielding a striped variety. This striped D 95 looks very much like the common Ribbon cane.

Since 1906 the Louisiana Sugar Experiment Station at Audubon Park, New Orleans, has been actively engaged in the production and testing of seedlings, using seed matured in the Tropics and sprouting it in the greenhouse under carefully controlled conditions as to heat and moisture. Several varieties of much promise have already been produced and multiplied in sufficient abundance for trial under field conditions. Among those favorably reported are L 511, L 218, L 219, L 231, and L 226, samples from all of which have been supplied through the kindness of Mr. W. G. Taggart, in charge of the Sugar Experiment Station at New Orleans, and are now being propagated by the United States Department of Agriculture at Apalachicola, Fla., and at Cairo, Ga. The tests in Georgia are in comparison with a number of the older varieties and some new seedlings from foreign countries.

Because of the great diversity of characteristics among sugar-cane seedlings, seedling production and testing is the most hopeful method of attacking many of the problems in sugar-cane production, such as the increase of sugar content, earliness of maturity, disease resistance, and adaptation to soil conditions. Since the soil and climatic characteristics in different cane-growing localities vary greatly, and since the success of cane varieties depends so much upon these characteristics, it is highly desirable to carry on the testing of seedling varieties in many different typical localities.

## SOIL REQUIREMENTS.

Since all varieties of cane make heavy demands upon the soil for plant-food constituents and water, the soil must be suitable to provide these under the conditions otherwise prevailing. If the rains are not well distributed and if periods of drought are to be expected without provision for irrigation, it is essential that the soil be a medium-heavy loam or a clay with an abundance of humus. If the soil is very sandy and lacks humus, it is practically impossible to supply the necessary plant-food constituents economically just when the plants need them, even if rains are abundant and well distributed. Such soils do not retain well the commercial fertilizers and therefore make necessary frequent applications and occasion much wastage.

While such sandy flats as those that occur so extensively near the southern Atlantic and eastern Gulf coasts can be made to produce big crops of sugar cane, this can not be done continuously without involving so much expense as to make it unprofitable. Frequently such land produces a fairly good crop while it is new ground and while the vegetable mold from the native forest growth supplies an abundance of humus. In succeeding years, after this is exhausted, it is only by the liberal application of mineral plant foods and of organic matter in the form of green-manuring crops and barnyard manure or their equivalent that good yields can be secured. It is otherwise with the so-called hammock lands and with the rolling lands farther from the coast, or with the delta lands near the rivers, where a considerable percentage of fine silt and clay is mixed with the sand, making a good loam or clay-loam soil. Too heavy a clay is likewise not well adapted for sugar-cane production, because it is practically impossible to keep it in good tilth. Thus, along the lower Mississippi River and the various bayous in Louisiana, the lands immediately adjacent to the streams are usually well adapted to sugar-cane production. These lands were formed by the sediment first deposited on occasions when these streams, during past ages, overflowed their banks, and they contain therefore much of the coarser silts and some sand. The land of the swamps lying farther back from these streams is composed almost entirely of a heavy clay, which is difficult to get in good tilth and is thus poorly adapted to cane culture. The conditions are vastly better if this clay has much vegetable mold or humus in it. In that event, provided the land is properly drained, good crops of cane can be grown so long as this supply of humus lasts.

The muck soils, provided they have a high mineral content, will produce big yields of cane if well drained. With muck land that is very low in mineral content or with peat land, it is doubtful whether it can be used successfully for sugar-cane production even if drained. A disadvantage with muck land is that it affords such poor anchorage for the cane roots that the cane very easily lodges, and this gives a tangled mat of stalks instead of relatively erect rows. In Georgia it is commonly reported that the rich dark soils along the edge of swamps, while producing high yields of cane, exert a deleterious effect upon the color, clearness, and flavor of sirup made therefrom. The farmers there, in consideration of the quality of sirup, prefer the lighter colored, loamy upland soils, suitably enriched with commercial manures, especially cottonseed meal.

In the low flat areas, where natural drainage does not keep the ground-water level 3 feet or more below the surface, it is essential that artificial drainage be provided. A depth to ground water greater than 3 feet should be attained if possible.

## MANURIAL REQUIREMENTS.

The use of commercial fertilizers in sugar-cane growing is almost universal in the United States and in other cane-growing countries. As to the particular feritlizer elements required and the forms and proportions in which they are applied, the various localities differ widely.

Some form of nitrogenous fertilizer can be applied with profit or is absolutely essential in practically all localities. The amount of nitrogen that is applied on the best-managed farms of the Southern

States usually ranges from 20 to 50 pounds per acre. In many of the tropical countries, where much larger yields are produced, this amount can be increased one or two fold with profit.

To the application of phosphoric acid there is a good response from the soils of nearly all sugar-cane localities both in this country and in foreign countries, but the amount to be applied most advantageously varies considerably. Most of the soils of Java are a notable exception to this rule, in that they do not respond to phosphate applications. The amount of soluble phosphoric acid applied in Louisiana is usually from 40 to 80 pounds per acre. To the lighter soils of Georgia and Florida it is not unusual to add considerably more, even up to 120 pounds per acre.

To applications of potash there is little or no response in most of the rich alluvial sugar-cane soils of the Mississippi Delta. In the States east of Louisiana, however, potash is applied, usually at the rate of 30 to 50 pounds per acre.

In these States it is common practice to buy the fertilizers ready mixed. However, many farmers do their own mixing in the interests of economy. In trade the mixed fertilizers are commonly described by three figures, referring in their order to the percentages of available phosphoric acid, ammonia, and potash which they contain. The mixtures most popular in southern Georgia and northern Florida for spring and early summer applications usually do not vary far from the 8–2–3 formula, i. e., 8 per cent of soluble phosphoric acid, 1.65 per cent of nitrogen (equivalent to 2 per cent of ammonia), and 3 per cent of potash. This is supplied in one or two applications in quantities totaling from 800 to 1,600 pounds per acre, often followed in late summer with a top-dressing of readily available nitrogen, such as nitrate of soda. These quantities are here mentioned as an example of common practice in one locality and not as a guide or recommendation for any wide range of soils or localities. It can not be too strongly urged that the farmer, in the absence of trustworthy and conclusive experience with his particular type of soil, should not blindly follow any special fertilizer formula that may have been found suitable for some other type of soil, but rather that he should experiment on his own farm on small plats with several of the combinations that he has reason to suppose will most probably fit his needs.

The most common sources of nitrogen in the manurial mixtures are cottonseed meal, tankage, and ammonium sulphate for early applications and sodium nitrate (Chile saltpeter) and ammonium sulphate for late applications. Of these, cottonseed meal is most extensively used in the Southern States, being near the source of its production the cheapest commercial fertilizer. It contains about 7 per cent of nitrogen, 3 per cent of phosphoric acid, and 2 per cent of potash. Tankage is also extensively used, especially at times when the price of cottonseed meal is unusually high. Its composition varies according to the proportions of blood, meat, and bone entering into its manufacture, but it averages about 7.5 per cent nitrogen and 5.5 per cent phosphoric acid. Dried blood and fish scrap are also occasionally used, mainly for their nitrogen content. In the tropical countries ammonium sulphate containing about 22 per cent nitrogen is very extensively used. For quickly available nitrogen, nitrate of soda (Chile saltpeter), containing about 15 per cent nitrogen, is the favorite. Synthetic nitrogen manures have been introduced recently to some extent.

The source of phosphoric acid in the fertilizer mixtures is nearly always acid phosphate, except to the extent that it is furnished by the nitrogenous manures, such as tankage or cottonseed meal. The acid phosphate contains 14 to 16 per cent of phosphoric acid. For soils deficient in lime and with an acid tendency, it is better to supply the phosphoric acid in the form of basic phosphate (basic slag or Thomas slag).

The potash was supplied in the past almost exclusively in the form of potash salts from the mines near Strassfurt, Germany, either the natural mineral, especially kainit with 12 to 14 per cent of potash, or the more nearly pure salts, the sulphate of potash and the chlorid (muriate) of potash, either one containing about 40 to 48 per cent of potash.

Natural manures, such as green crops plowed under and barnyard manure, are highly beneficial in increasing the yield of cane, much more so than the plant-food elements contained can account for. Practically all soils in the sugar-cane localities, both the heavy soils like these in Louisiana and the lighter ones of the States farther east, are very responsive to increases in the humus content. The farmer should therefore be on the alert to plow under vegetable matter whenever it is possible without interfering too seriously with cultivation. The tops and leaves from the cane at harvesting were in the past usually burned off to make the field cleaner for the cultivation of the stubble crop of cane during the next season and in the hope of thereby destroying insect pests. Recently, however, since the entomologists of this department have collected evidence which tends to show that the damage from insect pests is not reduced by burning the trash, many planters have adopted the plan of incorporating it with the soil without burning it. Whether or not this practice, and whether returning to the field the bagasse, suitably rotted or chopped fine, tends to increase the damage from diseases, remains yet to be determined, and experiments along this line are being instituted. It is common experience among cane-sirup makers that applications of barnyard manure, especially of horse-stable manure, to the cane crop injure the quality of the resulting sirup, making it darker in color and imparting a strong salty flavor. It is therefore advisable to make such applications to the cane crop sparingly where the cane is to be used for sirup production. In such cases it is good practice, if such manures are available, to make heavy applications to the crop preceding the sugar cane in the rotation.

In consideration of the quality of the sirup, cottonseed meal or even the cottonseed itself is a very popular manure for cane. Such practice, however, seems to be rather illogical, in consideration of the high food value which these substances possess. The cottonseed contains about 17 per cent of fat, which has no fertilizer value, but which if pressed out and purified has a high food value. The press cake remaining, if ground up, becomes cottonseed meal. If this is properly prepared it is an excellent high-protein concentrated foodstuff. In spite of the high food value of the oil and the high feeding value of the meal, the prices of these articles usually prevailing in the cotton sections are so low and their value as a fertilizer so high that they are both extensively used as fertilizers. Doubtless, with the upward trend in prices for animal products and with a fuller appreciation on the part of the farmers of the value of barnyard manure, these conditions will gradually change and more cottonseed meal will be fed and more barnyard manure will be produced to be available for crops in rotation with sugar cane.

## TIME AND MANNER OF APPLICATION OF FERTILIZERS.

Between what is theoretically best in the time and manner of application of fertilizers and what is least expensive, compromises must necessarily be made. To economize labor in distributing the fertilizers, the several constituents are usually mixed and distributed at one time. For cane planted in the spring it is customary to put a rather liberal application of mixed fertilizer, the nitrogen of which is in a form becoming gradually available, into the furrow in which the cane is to be dropped. Some implement is run through the furrow to mix this fertilizer with the soil. For cane planted in the fall or early winter the fertilizer is used very sparingly, if at all, at the time of planting, but the main amount is given in the spring when the crop starts to grow. In case of either spring or fall planting, another application is made near the middle of May, designated as a side application, in that it is distributed along the sides of the rows and cultivated into the soil. Many farmers favor giving a top-dressing of readily available nitrogen, e. g., nitrate of soda, at the time of laying the crop by, July 15 to August 1. Thus, a very common fertilizer program among the Georgia cane growers is to apply in the furrow at the time of planting 600 to 1,000 pounds of mixed fertilizer of a formula similar to the 8–2–3 formula before mentioned, then about the middle of May to give a side application of about two-thirds that amount of a similar mixture, and finally at the "laying by" of the crop to give a top-dressing of 100 to 200 pounds of Chile saltpeter. Many prefer to apply less of the mixed fertilizer at the time of planting and more later. It would doubtless be better for the cane if the same amount were divided into smaller quantities and applied more frequently, but this is generally considered to involve more expense than the gains justify.

## CROP ROTATION.

The fertilizer requirements depend very largely upon the crop preceding the cane. A very good practice is to precede the cane with a crop of corn and cowpeas, plowing the latter under. It is still better if this is done for two successive years. The common rotation on the sugar plantations in Louisiana has been one year of corn and cowpeas, followed by two years of sugar cane from one planting. With the growing interest in stock raising, some planters during the last few years have changed their system to a 4-year rotation, with two successive years of corn and cowpeas, plowing under the peas each time, then two years of cane. The results obtained were exceedingly encouraging, half of the plantation yielding almost or quite as much cane as previously two-thirds of the plantation did with a 3-year rotation.

In the principal sirup-producing sections, unlike the sugar plantations, the farmer can usually select a location for his cane patch that had a specially favorable treatment. Thus, for small patches a favorite practice is to shift the cowpen area from year to year and plow up the old area to plant in sugar cane. Very good results are obtained by manuring very heavily a field to put into sweet potatoes; then in the succeeding year planting it in cane. To obtain the requisite amount of manure, the cane bagasse (also called pomace or mash) is put in liberal quantities into the stables or corrals, to be worked up into manure, and then, after it has had about a year to rot, it is applied to the sweet-potato ground.

## PREPARATION OF THE LAND.

Not much need be said in regard to preparing the land that might not be said with equal propriety for any other crop. It is desirable to plow considerably in advance of the planting time, especially for spring planting, and then to cultivate well before planting. Grown on a clay soil with compact subsoil, cane is especially responsive to deep plowing, bringing into effective tilth a considerable depth of soil and opening the land for the storage of moisture. A reasonable depth to plow is 8 or 10 inches, with a subsoiler run through the furrow to a depth of another 8 or 10 inches. This deep cultivation is especially advantageous during seasons with periods of drought. In the experimental field at Cairo, Ga., in the season of 1915, the yield was fully twice that of adjacent fields, which could reasonably be attributed in large measure to deeper plowing and subsoiling, coupled with the fact that the season was characterized by very heavy rains in late winter and a drought of unusual severity in midsummer. With very sandy subsoil, lacking humus, deep plowing may be disadvantageous. With a clay subsoil which previously has always been plowed shallow, it is not advisable to turn up more than an inch of the subsoil at one plowing. It is better to attain the desired greater depth of plowing gradually, through a series of years, giving opportunity meanwhile for the inert subsoil that is turned up to become converted into a productive loam through mixture with surface soil and vegetable mold.

## PLANTING.

In Louisiana and parts of Florida it is deemed desirable to plant in the fall, as late as is safe to avoid frosts. However, for economic reasons the fall planting is done somewhat earlier, because after the harvesting for the mill commences the available labor and teams are fully occupied at that work. The fall planting therefore usually stops in the latter part of October, and what is not planted by that time is left to be planted in the spring as soon as the soil is in suitable condition to work and the weather is such as to occasion no fear of freezing the cane. In Louisiana this is usually in February or early March. Occasionally there is suitable planting weather in January. In Georgia and northern Florida the planting is almost universally done in the spring. The impression prevails that fall planting leads to an imperfect stand through the spoilage of cane during the winter. In the spring the cane may be selected so as to avoid using the spoiled stalks or portions of stalks. Availability of labor is also in favor of spring planting.

The advantages of fall planting are threefold:

(1) There is economy of labor. The cane is taken directly from the field where it is growing to the place where it is planted, thus avoiding the labor of storing it in windrows or banks and later digging it up to plant. (Fig. 5.)

(2) There is thought to be less spoilage of cane in the furrows than if planted in the windrows or banks.

(3) Fall-planted cane gets an earlier start in the spring, resulting in more mature and therefore richer cane at the time of harvesting and a slightly larger yield.

The spacing between the rows varies from about 4 to 6 feet. In the rich soils of Louisiana the usual spacing is 5½ to 6 feet. In southern Georgia 4½ feet is the most common spacing. The more rapidly the cane grows and the longer the growing season, the wider may be the spacing. It is desired that by midsummer, at laying-by time, the crop shall shade the ground well.

On the flat plantations in Louisiana, with the fields divided by permanent headlands and drainage ditches, it is customary to plow in beds, maintaining the same rows and consequently the same spacing from year to year. On the rolling uplands of southern Georgia and adjacent States there is need of special precautions against soil erosion. Besides terracing the land on the hill slopes, the rows are usually run on contour lines or so as to give them a fall of only 4 to 6 inches per hundred feet. If the field is terraced these terraces afford the necessary guide lines. If it is not terraced it is most advantageous to run guide lines every 3 to 5 feet of vertical rise in advance of laying off the rows. This may be done rapidly and very satisfactorily by a crew of three persons, using a small telescopic level, a suitable leveling rod, and a 1-mule marker. The man with the level directs the rodman up or down the hill slope until he has the proper altitude for the guide row that is to be run. (Fig. 6.) The rodman then steps off a distance of about 50 yards approximately on a level along the hillside. The man with the level again directs him up or down the slope until he has an elevation of 6 to 8 inches higher or lower than at the previous station. They thus locate a series of stations about 50 yards apart, each varying 6 to 8 inches in elevation from the preceding. The man with the marker meanwhile follows immediately behind the rodman, marking the gradually rising or falling contour

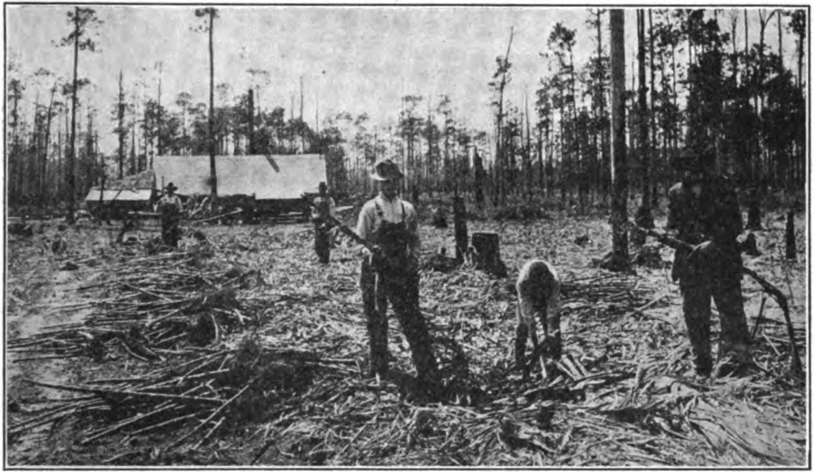
FIG. 5.—Stripping the sugar cane out of the bank ready for spring planting.

line along the hillside, guided by the stations marked by the rodman. A small telescopic farm level with tripod and leveling rod suitable for this purpose, constructed on the principle of the surveyor's level, can be purchased for about $20. The slope or direction of drainage of the furrows is ordinarily made from the center of the field toward both sides or is otherwise suited to the existing watercourses.

Most farmers prefer marking the rows, properly spaced, in advance of opening the furrows. This is usually done by a 1-mule 1-point marker (a "scooter") provided with a guide stick, hinged to the beam, to extend on either side the right distance to trace the next row.

After providing in one manner or another for the correct spacing and the course of the rows, the furrows are opened by using a 2-mule middle breaker (fig. 7, *b*) or by throwing out two furrows with a 1-mule turnplow, and then opening deeper with a 1-mule round shovel plow. The furrows are opened shallower in the flat, poorly drained fields of Louisiana. In the irrigated sections of Texas and Arizona the planting is extra deep. The commercial fertilizers and sometimes also the barnyard manure are distributed in the furrows (fig. 7, *a*). and mixed with the soil by again driving through with a suitable implement. The cane is then distributed (fig. 8) and covered to a depth of 1 to 2 inches in the case of spring planting, or about 4 to 6 inches in fall planting, by throwing light furrows on from both sides. In the latter case the covering is again raked off in the spring, leaving only 1 to 2 inches over the cane. Frequently the cane in the windrows or banks is more or less damaged by red-rot or some other disease. With reference to cutting away the diseased parts before

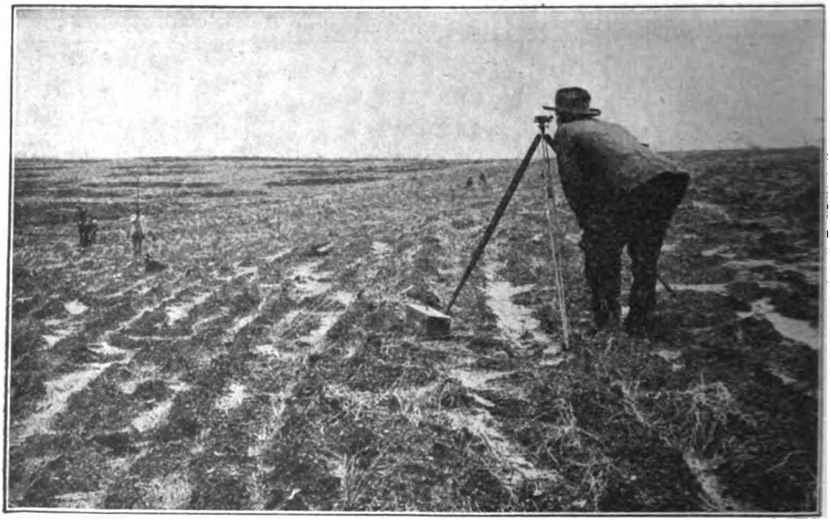

FIG. 6.—Running a guide line for sugar-cane rows along the hillside.

planting, practice varies. On the basis of ordinary field sanitation it is advisable to trim off the diseased parts and to plant only sound stalks. However, until it is determined whether the diseases in question are transmitted to any great extent through the plant material, there is some doubt as to the advantage in trimming.

The rate of planting in the row varies with the time of planting, the width of row, and the size and soundness of the cane. Ordinarily, with rows 4½ feet apart in Georgia and Florida, in spring planting the aim is to get as much as one continuous line of sound cane. If the cane is partly diseased it is lapped or doubled to make the line of sound cane complete. With good sound cane less than a complete line, as low as two-thirds or three-fourths of a complete line, will ordinarily give a satisfactory stand in 4½-foot rows. Cane has a strong power of adapting itself to the space given it, stooling out when planted thin, so as largely to compensate for thin planting. Therefore, if the plant material is scarce and the available area plentiful, e. g., in the multiplication of a valuable rare variety, it is advantageous to plant quite thin. In Louisiana, with 5½ to 6 foot rows and with the cane usually damaged both by diseases and by

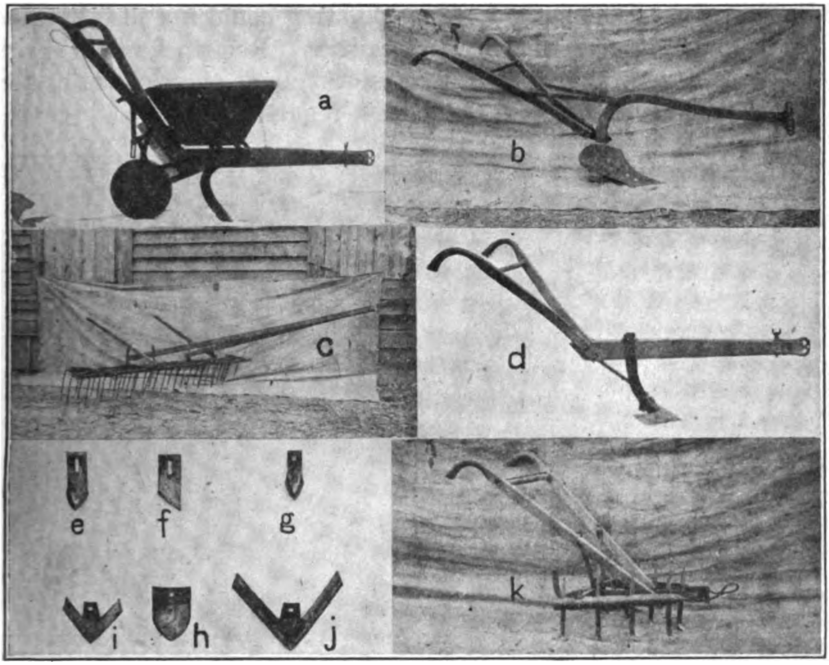

**Fig. 7.**—Some types of implements in common use for cultivating sugar cane on small farms: *a*, Fertilizer distributor; *b*, middle breaker; *c*, weeder; *d*, common 1-mule stock, with sweep point attached; *e*, *f*, *g*, scooter points; *h*, round shovel point; *i*, *j*, sweep points for stock (*d*); *k*, spike-tooth cultivator, useful for early cultivations.

borers in the stalks, the practice in fall planting is to put into the furrow about two lines (fig. 9) or "two lines and a lap," and in spring planting somewhat more, even up to three or four lines if the cane is in bad condition. In tropical countries, where the new growing season follows immediately upon the harvesting and planting time and the cane consequently need not lie dormant in the furrow or in storage through the winter months subjected to disease, it is common practice to plant only the tops of the stalks, which are less valuable for sugar manufacture and yet are quicker to start growing than the older, more mature parts of the stalks. It is still an open question whether or not some system of top planting could not also be used to advantage in our sugar-cane localities. Rootstock planting is sometimes resorted to, but with rootstocks alone the uncertainty in the germination is too great to assure a regular stand.

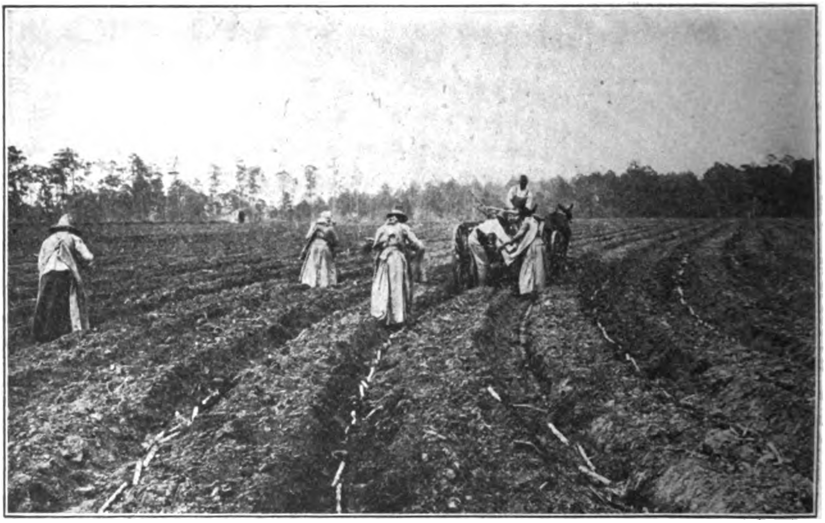

FIG. 8.—Planting sugar cane in Georgia..

About 3 to 4 tons of cane are usually stated as the requirement to plant an acre in Louisiana, where the whole stalks without rootstocks are used. In the States farther east, with a smaller acreage, it is customary to quote plant cane in actual numbers of stalks, with some definite length stated or implied as the average length, and upon the basis of such counts commercial transactions with seed cane are made. Prices are then quoted per 1,000 stalks. To plant an acre in 4½-foot rows, with a single complete line of stalks, 9,680 linear feet of plant material are required, or 2,420 stalks averaging 4 feet in length; and this may be taken as an average quantity of moderately good cane to plant. Such stalks, including the rootstocks, may be expected to weigh about 3 pounds apiece; hence, the weight of plant cane required is 7,260 pounds, or 3⅝ tons. Stalks without rootstocks of this quantity of cane if harvested for the mill would weigh about 3 tons. Thus, at best, the seed-cane requirement in the sugar-cane industry is a very heavy drain upon the net proceeds from the crop, and herein lies an incentive to Government or State experimental institutions for making strong efforts to find or originate cane varieties that are more resistant to disease and that will consequently not require such frequent replanting, or canes that stool better, so that the planting may be thinner. With Japanese cane this drain is far less, first, because this variety ratoons well, giving good yields for three to six years from one planting, and, second, because the stalks are so slender that a ton will go a long way in planting However, as heretofore stated, this variety is not very good for sirup or sugar making.

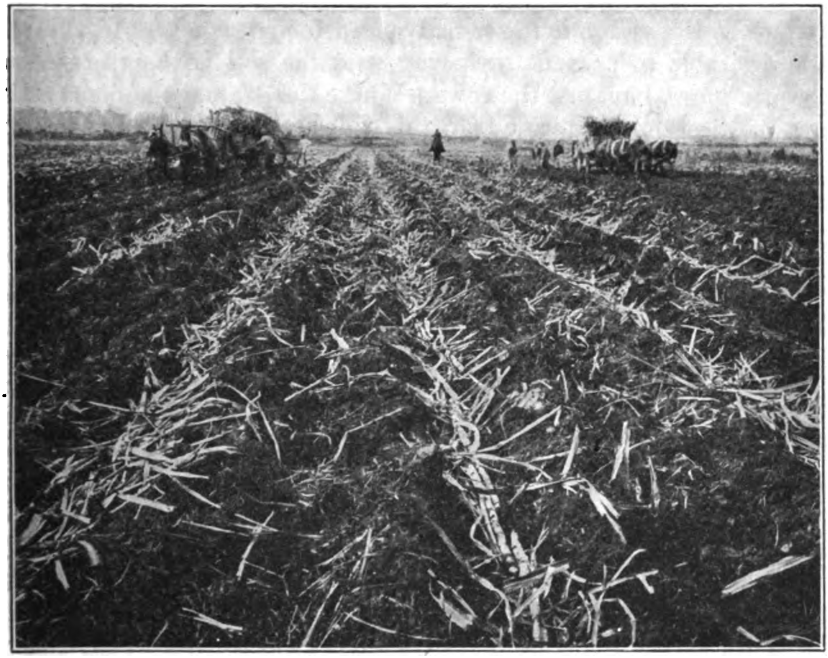

FIG. 9.—Planting sugar cane in Louisiana.

## CULTIVATING THE CANE.

If in the spring, before the newly planted cane is up or while it is still small, the ground gets crusted over badly or weeds tend to get a start, it is advisable to stir the soil lightly with a light spike-tooth harrow, or, still better, with a spring-tooth weeder (fig. 7, *c*), covering the field once or twice in a direction diagonal to the rows. If this does not remove the weeds, it is advisable after the cane is up to clean them out of the rows by hand hoeing. A second or third hand hoeing may be necessary later to keep weeds out of the rows. After the cane is well up, the space between the rows is cultivated to kill the weeds and to keep the soil in tilth, much as for any other crop. (Fig. 7, *k*.) The early cultivations, before the root systems have developed much, should be relatively deep, but later in the season shallow cultivation must be practiced, to avoid injuring the fine feeding roots that spread out from the cane near the surface. The suckering of the cane can be controlled to some extent by the cultivation. Throwing the soil toward the plants tends to restrain suckering. On the other hand, leaving the bases of the plants exposed favors suckering. Therefore, to get a good stand from the minimum of planting material, the soil is withheld from the rows as far as feasible during the early stages of growth. Later, however, when the season is too far advanced for new suckers to mature, it is desirable to prevent suckering, and the soil is therefore more liberally plowed against the rows. Where the drainage is poor, as in most of the Louisiana cane belt, this ridging up of the rows is carried to an extreme, leaving deep drainage furrows between the rows to carry off the surplus rainfall quickly. In irrigated sections, on the other hand, the farmers strive to keep the cane row low as long as practicable, to enable them to run the irrigation streams through the rows, probably coming up to about flat cultivation by the end of the first year.

The only difference in the cultivation of the fall-planted cane is to bar off as early in the spring as the weather and the condition of the soil will permit and to rake off about the time growth will start. To bar off means to plow a furrow away from each side of the row, usually with a 1-mule turnplow, leaving a ridge about a foot wide at the row in which the cane lies planted in the fall under a covering of 4 to 6 inches. This ridge is then raked off by hand with hoes or by cultivating crosswise with a harrow, leaving only 1 to 2 inches of soil over the cane.

If a stubble (ratoon) crop is to be taken, the stubbles receive some special attention. Shortly after harvesting, the trash is burned off (unless it is desired to incorporate it into the soil to increase the humus content), and the stubble row is "wrapped" by throwing a furrow toward it from each side with a 1-mule turnplow. The remainder of the space between the rows is plowed with a turnplow at the same time. In this condition it is left through the winter. The treatment in the spring is to bar off and to rake the stubble with a harrow, about as already described for fall-planted cane. On the big plantations in Louisiana, where the rows are on high ridges and the rootstocks consequently are relatively long, instead of thus raking the extra soil off the stubbles it is customary to "shave" them. For this a special implement is employed, having either a horizontal, obliquely placed, straight, flat cutting bar or two horizontal disks, to cut through the ridge left at the time of barring off and to cut off the partly decayed upper ends of the old rootstocks. Suitable plates on the implement brush the loosened soil into the furrow at the sides and thus leave the tops of the shaved stubbles exposed. This removes from the rows all the weeds and most of the weed seeds and thus aids greatly in keeping the row clean during the early growth of the crop. Later, and before the crop has made much progress in growth, it is advisable to loosen the soil with a special implement, the stubble digger. (Fig. 10.)

Neither stubble shavers nor stubble diggers have been adopted to any notable extent in the sirup sections east of Louisiana. As to the implements for further cultivation, practice in the sirup sections differs widely from that of the large plantations of Louisiana and from that with other crops in the Northern and Western States. After the preparation of the land, nearly all the work is done with 1-mule implements, using a 1, 2, or 3 point single cultivator in the early cultivation (fig. 7, *d* and *e* to *j*) and sweeps for the later shallow cultivation. To one accustomed to the 2-horse or larger implements used in other sections of the country (fig. 11), this farming with 1-mule implements seems like very inefficient utilization of farm labor. It has a partial justification, however, in the facts that the farms and fields are mostly small; that there are many short rows, especially where they are laid off along contour lines on the hill slopes; that no headlands for turning around are provided; and, finally, that the wages of laborer and mule are nearly equal.

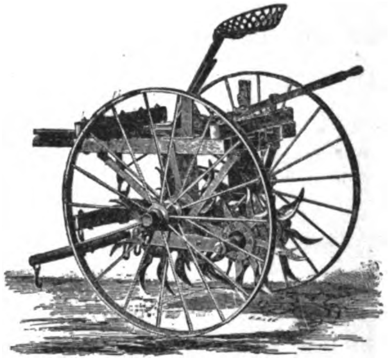

FIG. 10.—A type of stubble digger used for sugar-cane tillage in Louisiana.

When we consider, however, that not uncommonly the operations of marking the rows, opening the furrows, distributing fertilizer, and covering the cane require altogether eight trips of laborer and single mule along each row, there seems undoubtedly room for improvement in efficiency. Practically the same disproportion of trips per row to the work accomplished exists in the later cultivation in these sections.

Cultivation generally ceases and the crop is "laid by" about the middle of July or first of August. By this time the crop shades the ground and the rows have spread out until it is impracticable to get through with the single-mule implements.

## HARVESTING.

With the coming of cool nights and moderately cool days, which is usually in October, the cane matures rapidly, i. e., stores up sugar in the stalk. With suitable cool weather, the cane may be in condition to commence grinding by the latter part of October. Farmers in the sirup sections with but small crops to dispose of prefer to wait till near the middle of November. In southern Florida, where winter frosts are rare, they can afford to wait till December before commencing to grind. The later in the fall or winter the cane is harvested, provided it is not damaged by frost, the bigger the yield of cane and the higher the sugar content; therefore the better for the manufacture of either sugar or sirup. However, a slight degree of immaturity is not so objectionable for sirup making as for sugar manufacture. The immature cane, while containing less sucrose (common sugar), contains more of the reducing sugars, which lessen the tendency of sirup to granulate when boiled thick, a desirable property. It thus comes about that the sugar-cane industry for sirup making is carried to somewhat higher latitudes, i. e., colder climates, than for sugar manufacture. If, however, the cane is too immature, the sirup can not be made sufficiently clear and light colored and has an objectionably strong, bitter flavor.

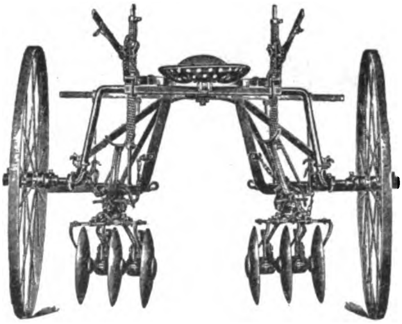

FIG. 11.—A type of 2-horse disk cultivator used on large sugar-cane plantations.

The operation of harvesting (fig. 12) consists of stripping the leaves off the stalk, topping the cane, cutting off at the bottom, dropping it in bundles, loading, and hauling to the mill. The stripping, topping, and cutting of the cane are usually accomplished by hand with a cane knife. This implement has a small hook at the tip of the back of the blade (fig. 13, *b*) that helps in raking or beating off the leaves with the back of the knife. About two strokes down the sides of the stalk will remove the leaves if the stalk stands straight. If it has been lodged by a storm and has consequently grown crooked, as is frequently the case with the old home varieties, it is more troublesome to strip off the leaves. Thus in the stripping, and in the further handling also, there is a decided advantage in growing varieties of rigid, erect characteristics, such as the D 74, which do not readily lodge. Some planters prefer to strip the cane a few weeks in advance of the actual harvesting, thinking thereby to hasten maturity. This, however, is of doubtful value except to get that much of the work disposed of before the busy harvesting time comes. The practices in harvesting in the eastern Gulf States differ somewhat from those in Louisiana and of cane-growing countries. Three different tools are used in stripping, topping, and cutting the cane, and the work is done in three stages. First, the cane is stripped by the use of a flat stick about 3 to 4 feet long or, better, with a tool consisting of two curved and forking narrow blades of spring steel on the end of a stick, so disposed that the operator can beat the leaves down from both sides of the stalk with a single stroke (fig. 13, *a*). The second operation, the topping, is done with an ordinary cane knife. Finally, the cane is cut off at the ground with a heavy, short-handled hoe (fig. 14).

Persistent efforts have been made by a number of very capable inventors to design and build machines to harvest the cane, and encouraging progress has been made. Stripping and topping the cane satisfactorily without making the machine unwieldy offer the great difficulty. Possibly we may hope for the solution of the machine-harvesting problem when means for utilizing the tops are worked out, e. g., siloing and feeding, so as to pay for their transportation to the mill or to some central loading station. Then the inventors could attack the problem of stripping and topping by means of stationary machines without being so closely limited in the weight or size of the machines.

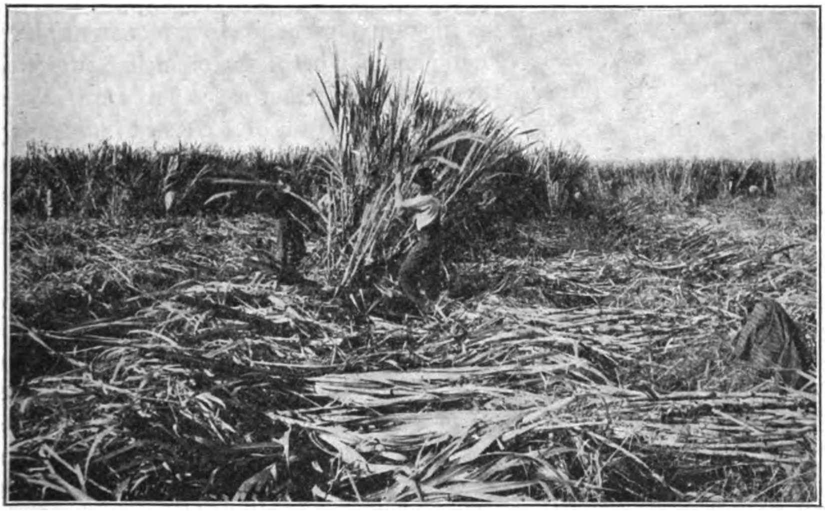

FIG. 12.—Harvesting sugar cane in Louisiana.

The loading of the cane is done by hand except on some of the large sugar plantations, where loading machines are in use, operated either by mules or, better, by gasoline power. (Fig. 15.) Suitable grabs and hoists pick up the cane from the small heaps into which the cutters have dropped it and swing it over, to be tripped off into the wagon box. The wagons or carts may be provided with slings to unload the cane at the mill or at the field railway by the use of power hoists.

A light frost on the cane may kill the leaves without seriously damaging the cane except to check its growth. A somewhat heavier frost that kills the growing tip and the eyes renders the cane worthless for planting, but occasions no serious loss for sugar or sirup manufacture if the cane is not left standing in the field very long. Fermentation proceeds but slowly from the injured tips and eyes, resulting in no serious deterioration if harvesting is delayed even for a week or two. If, however, a hard freeze, sufficient to freeze the interior of the stalks, catches the crop still in the field, then the rind of the stalks is burst open. If warm weather follows and the cane is exposed to it, fermentation beginning along the injured stalks will in a very few days cause a souring of the cane to an extent that makes it worthless for either sugar or sirup manufacture. In case of a heavy frost or of a freeze much may be done toward saving the cane or extending the time in which it can be ground profitably by promptly windrowing it. If possible, before the weather turns warm, the cane should be cut and laid in windrows, with the tops overlapping the stalks, the same as in putting away seed cane, but omitting the soil covering. The foliage will then protect the stalks in a measure from the heat of the sun, and fermentation proceeds much more slowly. Windrowing is the more effective if the cane is put down while it and the ground are cold. It is much better if the frost can be anticipated and the cane put in windrows just before the frost. Some deterioration will still take place, but it is relatively small. Of course the possibility of further growth is sacrificed. It thus occasionally happens that, with weather conditions threatening a freeze, or immediately following a freeze, the plantation manager shuts down the mill and puts all available hands at windrowing cane, working under pressure almost night and day until the cane is all down. It is later stripped out of the windrows and topped as fast as the mill can work it up. If the cane is not badly frozen and time permits, it is more economical and equally effective in protecting the cane to strip, top, and cut it, drop it in small heaps, and cover it with trash until it can be milled.

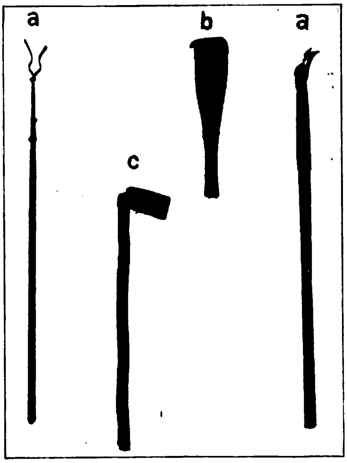

FIG. 13.—Harvesting tools used in Georgia and Florida: *a, a*, Stripping tools; *b*, cane knife; *c*, hoe.

## YIELD OF CANE, SUGAR, AND SIRUP.

For rich Mississippi Delta land, with good care and a good season, 25 to 35 tons per acre would be considered a fair crop from plant cane, i. e., the first crop from a planting. About two-thirds of this yield may be expected from the first ratoon crop (first-year stubble crop) and about one-half the plant-cane yield from the second ratoon crop (second-year stubble crop). In most sections farther east, with a lighter soil, the yields are lower, viz, about 18 to 25 tons per acre from plant cane under favorable conditions, and about two-thirds and one-half of this from the first and second ratoon crops, respectively.

The ratios here given between the yields of the plant-cane crop and the first and second year stubble crops are estimated to be the average ratios for all seasons and all farms; however, these relations are subject to great variations in different seasons and on different farms. Thus, in southern Georgia during the season of 1914 the stubble crops made an exceptionally good stand and growth, the first-year stubble on many farms exceeding in yield the plant-cane crop. The succeeding year, 1915, on the other hand, showed an equally abnormal divergence in the other direction, in that the first-year stubble crop on most farms yielded less than half of what the plant-cane crop yielded, while the stand of the second-year stubble crop in most cases was so poor in the spring that the farmers plowed up this cane and planted the fields in other crops.

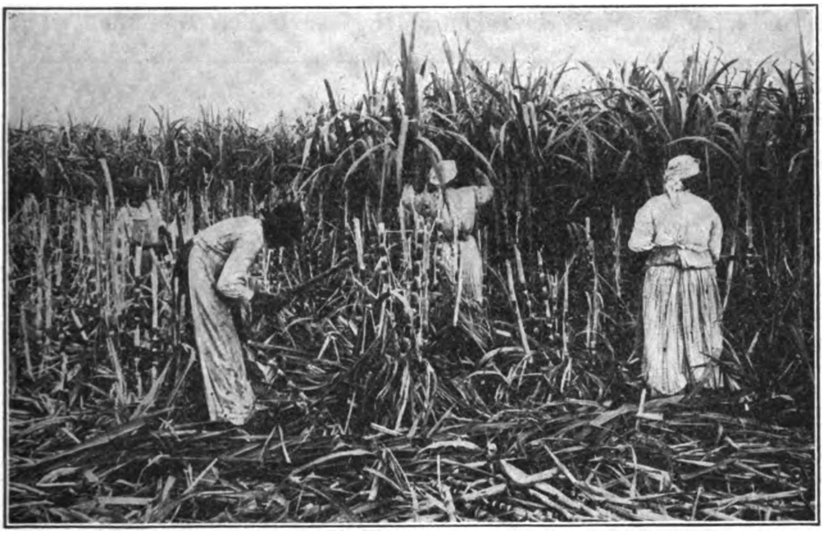

FIG. 14.—Harvesting sugar cane in Georgia.

The composition of the cane varies with the variety, the season, the time of harvesting, and other factors. It may be expected to contain on an average about 88 to 90 per cent of its weight in juice. The best modern sugar-factory mills with 9 or 12 rollers and with "saturation" (addition of water between successive pressings) can extract about 80 to 85 per cent of the weight of cane in juice. Power mills with a single set of three rollers may effect an extraction up to about 68 per cent. Those of small design, as used on the sirup-making farms, rarely exceed 65 per cent. The small mills driven by 6 to 8 horsepower gasoline engines usually give an extraction of 55 to 65 per cent, and the horsepower mills frequently even less. With average cane and good management of the mill, the extraction, even with these small mills, should not be below 58 to 63 per cent of the weight of the cane.

The sucrose (common sugar) content of cane is especially subject to variation with degree of maturity, seasonal conditions, etc. About 11 to 14 per cent may be taken as the usual sucrose content of the juice in the Southern States. Accompanying the sucrose we may expect to find 1.5 to 2 per cent of reducing sugars (dextrose and levulose, frequently spoken of as glucose). In the earliest part of the harvest season the sucrose content is lower and the reducing sugars higher than they are later. With good mature cane, such as is usually produced in tropical countries, the reducing sugars almost vanish. Besides these sugars, the juice contains from 1.3 to 2 per cent of solids other than sugar. With the usual losses in extraction and other unavoidable losses in the manufacture of sugar and sirup, the actual yield of sugar under favorable conditions in a large factory is 140 to 180 pounds per ton of cane, or about 2 to 2.8 tons of sugar per acre of good plant cane on Mississippi River Delta land. The actual yield of sirup is about 18 to 24 gallons per ton of cane, or about 400 to 525 gallons, equal to 12 to 16 barrels of sirup, per acre

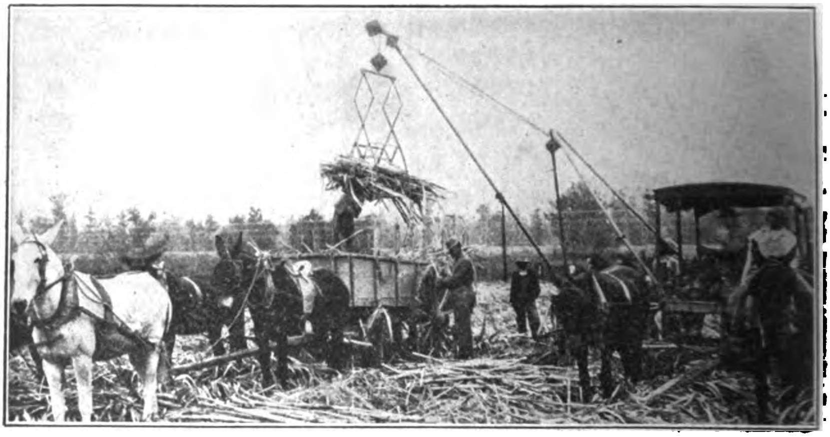

FIG. 15.—A gasoline-power sugar-cane loader.

of plant cane on good Georgia or Florida farms. The average yields, as shown by the census reports, are much below these, showing that many farms and factories are not producing yields up to the normal for good, well-managed farms.

## STORING CANE FOR PLANTING.

In localities subject to winter frosts, if the new plantings of cane are not made in the fall, planting the cane directly from the field as it is harvested, some means must be employed for storing the cane until time to plant it, which is usually in the spring. Two somewhat different modes of storing are in common use, viz, windrowing and banking. Practice also varies, some preferring to dig up the cane and store it with the rootstocks left on, while others, to save labor, are content to cut the cane about even with the surface of the ground, thus sacrificing the short rootstock, which bears a large number of eyes.

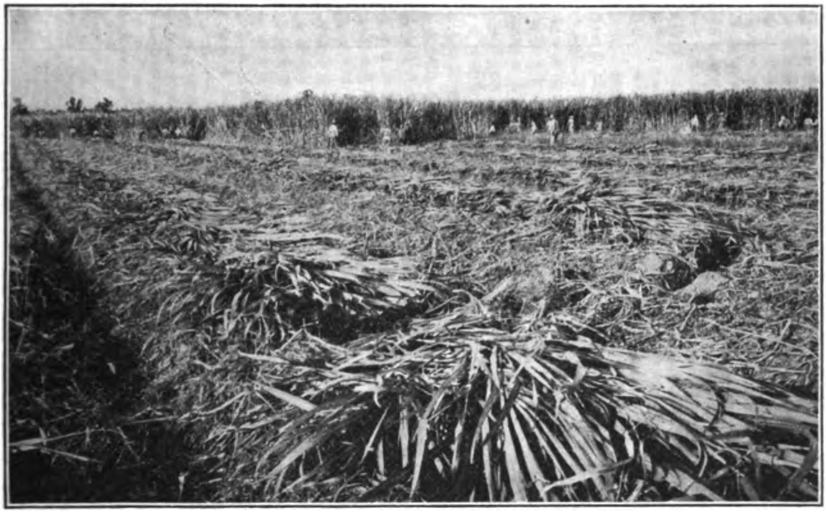

FIG. 16.—Putting sugar cane in windrows in Louisiana.

Windrowing is generally practiced on the large sugar plantations, like those in Louisiana, where large quantities of cane are to be stored in a relatively short time. (Fig. 16.) The ridge cultivation results in deep furrows being formed in the middles between rows during cultivation. The cane from two or three rows, cut off at the ground and without removing the foliage, is laid into one of the middles, overlapping in such a manner that the tops always cover the stalks previously laid down. The windrow thus formed is covered with soil by the use of large plows, throwing about two furrows from each side over it. If the soil is cloddy or wet, a disk cultivator is sometimes driven over the windrows to smooth out the soil that the plows have thrown up, and finally hand hoes are employed to cover such gaps as the plows and cultivator failed to cover. At planting time the cane is pulled out of these windrows by the use of a mule pulling a specially constructed implement with prongs or hooks crosswise of the rows. The storage of cane by banking is similar to windrowing in principle, but the layer of cane is usually deeper and the space covered wider. The depth of the cane in the bank before covering is from 18 to 30 inches and the width from about 5 to 10 feet. The length of these banks is governed by convenience. Only the edges can be covered with plows and the center strip of the bank must be covered by hand with shovels. (Fig. 17.) About 1 to 2 inches of soil is put on the bank. Some prefer to leave a strip of about 8 inches in the middle of the bank uncovered until colder weather or all winter. At planting time the soil is shoveled off these banks and the cane pulled out by hand and stripped of leaves and topped. It is thus seen that banking the cane, while possibly somewhat more economical of planting material, requires proportionally much more hand labor, and it can therefore be practiced only where the cane areas are small and the labor available is relatively abundant.

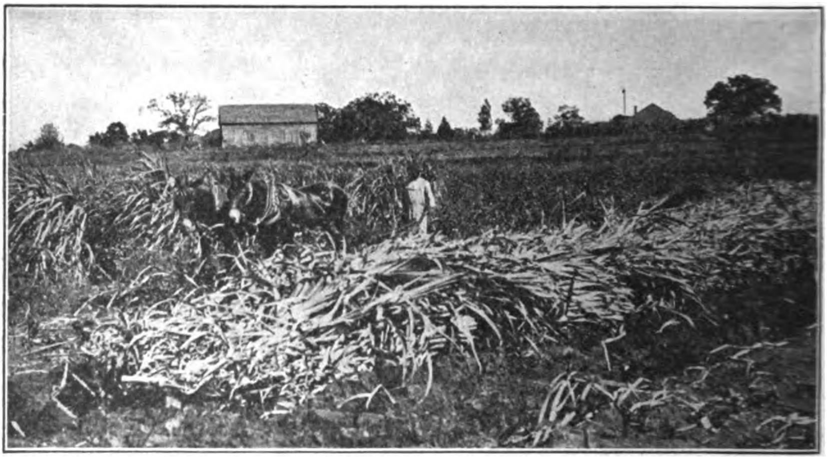

FIG. 17.—A bank of sugar cane in Georgia ready to cover.

Whether the cane is to be banked or windrowed, it is necessary to take every precaution to see that it is well matured and kept as cool as possible in storage. The nonavailability of labor while harvesting for the mill and the danger from frosts lead the planters usually to store the seed cane before beginning to harvest for the mill, thus sacrificing some in maturity of the cane. Cool, wet days are chosen, if possible, for the work of storing. If it must be banked when the ground is warm and dry, it is advisable to scrape away the warm and dry surface soil immediately before putting down the cane.

## INSECT PESTS AND DISEASES OF CANE.

The reader is referred to other publications for details in regard to insect pests and diseases that are likely to infest sugar cane.[1] In this more general treatment of the subject, however, attention will be called to a few of the more dangerous pests and diseases that the farmer should avoid if possible.

The moth borer (*Diatraea saccharalis*) is by far the most destructive insect pest with which cane growers have to contend. It infests the fields throughout most of the Louisiana cane belt and parts of Texas. East of Louisiana it has been found in only a few rather restricted localities. The moth lays its eggs on the leaves of the cane and the larvæ from the eggs bore into the stalk, reducing the yield of cane and, much more, the yield of sugar or sirup from it and killing many eyes of the cane stored for planting.

The mealy bug (*Pseudococcus calceolariae*) comes next in importance in regard to the damage done in the cane areas of the United States. It is widespread in the Louisiana cane districts and does much damage to the cane. These bugs collect around the stalks of the cane, mostly near the joints, and suck the juice out of the cane. They are covered with a downy white fuzz, making it appear as if the stalk were covered with a white mold. It is practically impossible by any means yet worked out to eradicate either the moth borer or the mealy bug when once they have become well established in a cane-growing locality. For localities not infested, an ounce of prevention is worth many pounds of cure. Great caution should be exercised to prevent their introduction. Cane for planting or other purposes should not be imported to a free section from an infested section except under the direction of an expert.

Termites, also called wood lice and white ants, at times do some damage to cane. They are most likely to occur where there is much coarse vegetable matter in the soil, therefore in new-ground fields. Fertilizing by dropping raw cottonseed in the furrow at planting time frequently leads to increased damage to the cane from the termites. They enter the growing stalks from the planted cane, causing hollows which become surrounded with hardened tissue. Usually, if termites get started in a planted stalk, they enter all the young stalks sprouting from it. For this reason it is recommended, in fields where they give trouble, to cut the stalks for planting into short lengths, 12 to 18 inches, and to drop these pieces in the furrows somewhat diagonally or otherwise, so that the ends will not touch.

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[1] Holloway, T. E. Insects liable to dissemination in shipments of sugar cane. U. S. Dept. Agr., Bur. Ent. Cir. 165, 8 p. 1912.

Field, Ethel C. Fungous diseases liable to be disseminated in shipments of sugar cane. *In* U. S. Dept. Agr., Bur. Plant Indus. Cir. 126, p. 1–18, 7 fig. 1913.

Of sugar-cane diseases the one causing by far the greatest damage in the United States is the red-rot, caused by the fungus *Colletotrichum falcatum.* This disease is distributed throughout most of the sections where cane is extensively grown. The most serious damage from it has been reported from Louisiana and from the sections of southern Georgia and northern Florida where large areas are devoted to sugar cane. It does not seriously damage the growing cane or affect its sugar content, but it has caused great losses in the banks or windrows while in storage for spring planting. In recent years on some farms it has frequently caused losses ranging from 25 to 75 per cent of the cane put away. Until the nature of this disease, the manner of its propagation, and effective means for its control have been better worked out for our climate it is advisable to employ ordinary measures of field sanitation, such as (1) to avoid, as far as feasible, the devotion of the same area to cane without an interim of several years of planting to other crops; (2) putting away seed cane from new ground or from areas where there is reason to think the infection is not so great; and (3) trimming away the badly diseased portions of the stalks at planting time. It should be said, however, that it is not at present known to what degree these measures are efficient in lessening the damage from red-rot.

Root-rot (*Marasmius sacchari*) is responsible in some localities for considerable reductions in yields and especially for the dying out of stubbles, resulting in a poor stand. In the growing cane that is diseased it is noticeable in the earlier stages and in wet weather as a slimy growth between the leaf sheaths and the stalks near the ground, and later by a cementing of the lower leaf sheaths to the stalks with a whitish mold. In putting away seed cane such stalks, or at least the affected lower ends of them, should be rejected.

A number of other dangerous diseases and insect pests of sugar cane have appeared in many foreign countries, so that it is unwise to bring cane from any foreign country except through approved quarantine stations. Recognizing these dangers, the Federal Horticultural Board has instituted a strict quarantine against cane from all foreign countries. Any proposed exceptions to this quarantine against individual countries or parts of countries will have to be considered by this board on their merits, exemptions being made only after it is ascertained that the localities in question are free from dangerous diseases and pests or after methods of treatment are worked out which can be depended upon to exclude them. For the introduction of small quantities of cane of hopeful new varieties for propagating and testing, an avenue is open through the United States Department of Agriculture. They will be propagated under suitable quarantine isolation until it is ascertained that the samples harbor no dangerous pests or diseases.

The risk incurred in introducing cane from other regions is illustrated by an incident that occurred a few years ago. The United States Department of Agriculture introduced a small mail shipment of cane of a rare variety from Hawaii for propagation in Porto Rico, observing the precaution of planting it the first season in one of our quarantine greenhouses. In spite of the fact that the cane had been carefully selected and prepared for shipment by an official of the Hawaiian Sugar Planters' Experiment Station and that when the package arrived at Washington, D. C., it seemed to be free from pests and diseases, it developed during that season an abundant crop of the Hawaiian leafhopper, one of the most destructive insect pests that have ever been known to attack sugar cane. This simple precaution, which led to the subsequent destruction of the cane, doubtless saved the Porto Rican planters from losses by this pest such as the Hawaiian planters suffered, amounting in Hawaii at one time to millions of dollars annually and threatening the complete destruction of their great sugar industry.

## SOME BUSINESS CONSIDERATIONS IN CONNECTION WITH THE SUGAR-CANE AND SIRUP INDUSTRY.

One of the first questions that a new settler in a sugar-cane and sirup-producing section will ask is "What profit can be expected from this branch of the farm business?" Even the old settlers and old sirup producers as a rule can profit by making a closer study of the farm-economics side of their industry. The publication here of data on the business side of the industry, collected from some of the best-informed farmers in the sirup belt of southern Georgia and northern Florida, may therefore be of interest. The subject will be considered under the several headings: (1) Equipment and capital invested, (2) cost of producing the cane, (3) cost of manufacturing the sirup, and (4) value of products and profits.

### EQUIPMENT AND CAPITAL INVESTED.

Sugar-cane growing requires the best of land that the sections in question afford. While vast areas of land in these States can be bought at $10 an acre and less, it is not to be expected that such cheap lands have much value for cane production. There are large areas of flat coastal plains that are too sandy for profitable cane culture. One must expect to pay from $20 to $60 for good cane land in Georgia or Florida and about double this price in Louisiana. Good land well located for citrus fruits would command higher prices, and consequently would hardly be used for cane. Additional allowance must be made for the investment in improvements. To cover the interest on the land investment, together with expenses for upkeep, taxes, etc., the farmers in computing the cost of production of the cane in sections east of Louisiana must allow about $2 to $4 an acre as the annual rent for the land.

The implements required in the present practices in these localities are about the same as for other field crops, e. g., corn or cotton, and usually include small and large turnplows, middle breakers, harrows, a weeder, various forms of 1-mule cultivators with one or more points, a fertilizer distributor, and wagons; also hand implements, including hoes, shovels, etc. About the only special implements required for the cane are the cane knives and the stripping tools. Under such circumstances as have been suggested under the headings "Preparation of the land" and "Cultivating the cane" the farmer may add to his equipment a disk plow, a subsoiler, and 2-horse cultivators. There is thus to be charged to the sugar cane for implements such proportion of the total equipment of the farm as the area of sugar-cane land bears to the total area of cultivated land on the farm, or somewhat more, because the cane requires more work. The same may be said of the equipment in the line of work animals. In computing the cost of production of the cane in this bulletin the interest on the investment for work animals and implements is presumed to be covered by the expense for mule hire and labor.

It is proposed in another bulletin to give a detailed discussion of the sirup-making equipment. A summary only can here be given. An equipment very commonly used for small farms with the approximate cost of the several items consists of the following:

| | |
|---|---|
| Mill with three rollers, each 1 foot long | $125 |
| Gasoline or kerosene engine of about 6 horsepower | 250 |
| Evaporator, galvanized iron, 15 feet long and about 42 inches wide, with baffle plates and skimming troughs | 20 |
| Bricks (about 2,500) and lime (3 barrels) for building the hearth furnace for the evaporator, together with belt, juice receptacle, juice pipes and valves, and sirup receptacle | 100 |
| Material and labor for shelter and labor for building the furnace | 105 |
| Total | 600 |

The capacity of such an outfit would be about 6 barrels per day of 12 hours, disposing of one-third to one-half an acre of good cane a day. Assuming a 24-day grinding period, this outfit would suffice for a cane area of 8 to 12 acres.

For a small acreage, up to 3 or 4 acres, a horse mill and a round-bottom iron kettle outfit are frequently used, especially in old installations, the total outfit, including shelter for the kettle, costing about $125. For a larger area than 12 acres the tendency now seems to be to put in additional evaporators of the kind first mentioned and to install a larger mill, using steam power. Others, in order to secure a higher capacity, prefer to put in a steam outfit, including a boiler, steam engine, and steam vats for boiling the sirup. Such outfits with capacities ranging from 10 to 18 barrels of sirup per day of 12 hours (or more than double that capacity per day of 24 hours) may be estimated to cost from $2,000 to $6,000.

### COST OF PRODUCING THE CANE.

Estimates of the cost of individual items in the production of sugar cane and sirup were obtained by the writer from many practical farmers in the sirup sections. These estimates varied somewhat as to itemization and operations, but the detailed statements of two of them, selected as representative, are here reported in full.

#### DETAILED ESTIMATE BY A GEORGIA FARMER.

The first of these detailed estimates was given in 1914 by a farmer in southern Georgia, basing the calculation on his extensive experience in cane culture and sirup manufacture, operating on a scale that would there be characterized as extensive. All common labor is computed at 75 cents a day for men and 50 cents a day for women. Mule hire is computed at 75 cents a day. To prepare the land, it is calculated that 1 man and 3 mules with a disk plow will break 2 acres a day, making the cost per acre as follows:

| | |
|---|---|
| Breaking | $1.50 |
| Harrowing | .50 |
| Laying off, marking, and opening the furrows | 1.00 |
| Total (to prepare the land for planting) | 3.00 |

In planting, a crew sufficient to plant about 6 acres a day is employed and the expense is computed as follows:

| | |
|---|---|
| Hauling cane (4 men and 8 mules), hauling fertilizer (1 man and 2 mules), distributing fertilizer and helping to cover (1 man and 1 mule), covering (1 man and 1 mule); total for 7 men and 12 mules at 75 cents each per day | $14.25 |
| Stripping the cane, cutting it into short lengths, and trimming off diseased portions (25 women), dropping the cane in the furrows (6 women); total for 31 women at 50 cents each per day | 15.50 |
| Overseers, two, at $1.25 each per day | 2.50 |
| Total (cost of planting 6 acres) | 32.25 |
| Cost of planting 1 acre | 5.38 |

The cultivation and cost of fertilizer are computed as follows: Hoeing twice by hand, $1; six cultivations, 1 man and 1 mule covering 3 acres a day at each cultivation, for 2 days, $3; hauling and distributing fertilizer for second application, 50 cents; total cost of fertilizer, 1,500 pounds (10–3–5 formula), at $20 a ton (the normal wholesale price before the European war), $15.

Harvesting costs about $5 per acre. Hauling to the mill, assuming that the average distance is three-fourths of a mile and that 1 man and 2 mules will haul about eight loads a day, will be about $5 per acre.

Summarizing, the cost per acre, according to this farmer's estimates, is as follows:

| | |
|---|---|
| Rental of land | $2.50 |
| Seed cane in the banks | 10.00 |
| Breaking the land, harrowing, and marking and opening the furrows | 3.00 |
| Preparing the cane, hauling, and planting | 5.38 |
| Hoeing by hand | 1.00 |
| Cultivation | 3.00 |
| Second distribution of fertilizer | .50 |
| Total fertilizer, 1,500 pounds | 15.00 |
| Harvesting | 5.00 |
| Hauling to mill | 5.00 |
| Additional time of overseers | 3.00 |
| Total cost of 1 acre of cane delivered at the mill | 53.38 |

The allowance made for mule hire, 75 cents a day, is the usual rate. With good management, however, employing the mule profitably 200 days a year, the expenses for mule hire may be somewhat reduced, as is shown by the following computation made by the same farmer: Original cost of mule old enough to work, $250; average length of service of a mule, 10 years, with $75 per year for his keeping, $750; total cost for 10 years' service, $1,000. Assuming that the mule is employed profitably 200 days per year, the cost per day is 50 cents. However, as the time that the mule is actually employed profitably rarely averages 200 days per year, and to cover also the rental and deterioration of implements, the allowance of 75 cents a day is reasonable.

### ANOTHER DETAILED ESTIMATE, BY A GEORGIA FARM MANAGER.

Another detailed estimate of the cost of cane production was obtained from the manager of a large estate in the same locality. He allowed the same wages for common laborers and for mules as was allowed in the preceding estimate, viz, 75 cents a day for men and mules and 50 cents a day for boys and women. He employed less labor, but for fertilizer he allowed more, making the total practically the same.

| | |
|---|---|
| Breaking the land (1 man and 2 mules with a turnplow, about 3 acres a day); cost per acre | $0.75 |
| Laying off the land (running occasional guide lines along hill slopes by the use of a farm level, leveling rod, and marker, 1 man at $2 a day, 2 men and a mule at 75 cents each per day); total $4.25 a day (to lay off about 30 acres); cost per acre | .15 |
| Opening the furrow (with a spacing rod attached to the beam of the middle breaker, or judging the distance between rows by the eye, 1 man at $1 a day with 2 mules); total $2.50 a day (to open the furrows of about 7 acres); cost per acre | .35 |
| Planting (stalks not cut in short lengths nor diseased parts trimmed off, with 5 women to take the cane from the banks and strip it, 1 man and 2 mules to haul it, 6 women to drop it in the furrows, 1 man and 1 mule to cover, 2 overseers at $1.50 and $2, respectively); total $12.75 a day (to plant about 5 acres); cost per acre | 2.55 |
| Commercial fertilizer, 9–2–3 mixture (first application, 800 pounds per acre in the furrow at planting; second application, 500 pounds during cultivation; third application, 500 pounds at laying-by time); total 1,800 pounds, at $22.50 per ton | 20.25 |
| Distributing the fertilizer by hand (with 2 men and 2 mules hauling and 2 boys and 2 women distributing); total $5 a day (to cover 6 acres at each distribution); expense per acre (3×⅙ of $5) | 2.50 |

Summarizing the above, together with the other items involved, the cost per acre is shown to be as follows:

| | |
|---|---|
| Rental of land | $2.50 |
| Breaking the land | .75 |
| Harrowing | .25 |
| Laying off guide rows | .15 |
| Opening the furrows | .35 |
| Preparing, hauling, and planting the cane | 2.55 |
| Cane, 5 feet long, 2,000 stalks, at $5 per 1,000 | 10.00 |
| Fertilizer, 1,800 pounds, at $22.50 per ton | 20.25 |
| Hoeing twice by hand | 1.00 |
| Cultivating 6 times | 2.00 |
| Distributing fertilizer 3 times | 2.50 |
| Harvesting | 5.00 |
| Hauling | 5.00 |
| Additional time of overseers | 2.00 |
| Total cost per acre of cane delivered at mill | 54.30 |

### SUPPLEMENTARY CONSIDERATIONS.

The estimates of a farmer in northern Florida who computed rent, labor, and seed cane much higher and fertilizer lower give a total of $69 an acre.

On smaller farms where the farmer and his family do much of the work the cost per acre will be about the same if reasonable wages are allowed for their time.

The total cost of production will be changed but little if seasonal conditions cause the yield to be extra small or extra large. Only the harvesting and hauling expenses would be decreased or increased.

The amount charged for seed cane, $10, assumes that there was only a moderate loss in storage. If the cane kept very well, this amount would be less, and if it kept very poorly, as has often happened in recent years, it would be more.

The cost of producing the first stubble crop is, of course, considerably less, owing to the fact that all expenses for preparing the land and planting are avoided, amounting in the first of the above calculations to $18.38. In its place, however, would come the relatively small expense of "wrapping the stubble," plowing the middles, barring off, and raking off the stubble, amounting to about $3.50 per acre. Since a poorer stand and a smaller crop are to be expected, the amount of fertilizer applied is also less. This reduction may be estimated at $4 an acre. The harvesting and hauling expense would be reduced about $1.50. Thus the cost of the stubble crop per acre would be about $53.38—($18.38+$4+$1.50)+$3.50=$33.

For the second-year stubble crop, with a further reduction of $2 in the fertilizer, harvesting, and hauling expenses, the cost would be about $31 per acre.

If we assume that $54 per acre is the cost of producing the first or plant-cane crop and delivering it at the mill, and if we further assume a yield per acre of 22 tons of cane and from it 15 barrels (equal to 495 gallons) of sirup, the computed cost of producing the cane and delivering it at the mill will be—

| | |
|---|---|
| Per ton of cane | $2.45 |
| Per barrel of sirup | 3.60 |
| Per gallon of sirup | .11 |

Similarly, if we assume that $33 per acre is the cost of producing the first-year stubble-cane crop, and if we further assume a yield per acre of 15 tons of cane and from it 10 barrels (equal to 330 gallons) of sirup, the computed cost of producing this crop of cane and delivering it at the mill will be—

| | |
|---|---|
| Per ton of cane | $2.20 |
| Per barrel of sirup | 3.30 |
| Per gallon of sirup | .10 |

Again, assuming that the cost per acre of the second-year stubble crop is $31, as above, and assuming a yield of 11 tons of cane and from it 7.3 barrels (equal to 240 gallons) of sirup, the computed cost of the second stubble crop delivered at the mill will be—

| | |
|---|---|
| Per ton of cane | $2.82 |
| Per barrel of sirup | 4.25 |
| Per gallon of sirup | .12 |

The assumptions as to the cost of production and yields made in the above calculations are based on good land under good management. In actual practice, the yields average considerably lower without a proportional decrease in the expense per acre. It will be noted that under the above assumptions the first-year stubble crop is produced more economically and the second-year stubble crop less economically per unit of the product than the plant-cane crop.

### COST OF MANUFACTURING THE SIRUP.

Without going into details in this bulletin with respect to the manufacture of sirup, it must suffice here to give merely a summary of the manufacturing expenses, under two sets of conditions, viz: (1) With the small farm outfit, which includes a mill driven by a gasoline or kerosene engine and an evaporator of the Cook type; and (2) with the larger steam outfit, suitable for large farms. With the smaller of these two outfits, costing, as indicated under "Equipment and capital invested" (p. 34), about $600, the annual allowance for interest on investment, repairs, and deterioration should be about 22 per cent of the original cost. With the larger or steam outfit, assumed to cost $5,000, about 17 per cent should be allowed.

With the smaller outfit a capacity of about 6 barrels of sirup per day of 12 hours may be assumed. Assuming a grinding period of 24 days each year, the amount chargeable to each day of operating for interest on investment, repairs, and deterioration will be $600×0.22÷24, or $5.50. To operate such an outfit, putting the sirup into barrels, not cans, a crew of four men is required, with wages totaling about $4 a day.

Summarizing these and other items, the estimated cost per day to operate this plant will be as follows:

| | |
|---|---|
| Interest on investment, repairs, and deterioration | $5.50 |
| Wages of crew of 4 men | 4.00 |
| Gasoline, 9 gallons at 20 cents | 1.80 |
| Fuel (good-quality wood) for boiling, 2 cords at $1.50 | 3.00 |
| Six empty barrels at $1.25 | 7.50 |
| Total manufacturing expense: | |
| Per day, producing 6 barrels of sirup | 21.80 |
| Per barrel | 3.63 |
| Per gallon | .11 |

With the large steam outfit, assumed to cost $5,000 and to have a capacity of 40 barrels a day, running 24 hours a day on a double shift, with a crew of 8 men on each shift operating 24 days in the year, the daily expenses would be about as follows:

| | |
|---|---|
| Interest on investment, repairs, and deterioration ($5,000 ×0.17÷24) | $35.42 |
| Wages of two crews of 8 men each | 22.00 |
| Fuel (second-quality wood, but a long haul), 15 cords, at $1.50 | 22.50 |
| Forty empty barrels at $1.25 | 50.00 |
| Total manufacturing expense: | |
| Per day, producing 40 barrels of sirup | 129.92 |
| Per barrel | 3.25 |
| Per gallon | .10 |

Comparing the figures for the two outfits the following will be noted:

(1) The charges for interest, repairs, and deterioration are higher per barrel capacity in the large factory, because of the relatively larger amount invested.

(2) The labor employed is of a more expensive character in the large factory. The total outlay for labor, however, is less per unit capacity.

(3) A lower grade of wood can be used in the steam plant. However, the larger quantity needed necessitates hauling it for longer distances, thus making the cost per cord about the same. The total expense for fuel in the steam plant is considerably less per unit capacity than that of wood and gasoline combined in the small outfit.

(4) Upon the whole, the large steam plant, operating night and day, produces sirup at a cost of about 38 cents per barrel (or 1 cent per gallon) less than the small outfit, operating only 12 hours a day.

If the steam plant were operated only 12 hours a day the daily fuel consumption would be more than half and the daily sirup capacity would be less than half the estimates given, so that the large steam plant would be operated at an expense per barrel fully as high as that of the small outfit. An advantage, however, of the large outfit not shown in the operating costs is the fact that the mill would be more powerful, resulting in a higher extraction of juice from the cane, equal to about 4 or 5 per cent of the weight of the cane, thereby increasing the sirup yield from 5 to 7 per cent. In this increased yield appears to be the principal advantage of the big steam plant over the small outfit when both are run intermittently 12 hours a day.

### VALUE OF PRODUCTS AND PROFITS.

Under the preceding two headings calculations were made upon the cost of production of the cane crop and of the sirup therefrom, basing the calculations mainly upon the experience in actual practice of well-informed farmers of southern Georgia and applying to a well-managed farm in that locality having good soil. In Table II are brought together the figures thus obtained, together with the calculated total cost of the finished sirup per acre, per barrel, and per gallon. The total cost is obtained by adding the cost of the cane, the expense of manufacture, and an allowance of 1 cent per gallon as the expense of marketing the sirup in bulk. For the expense of manufacture, the figures applying to the small outfit under the preceding heading, viz, $3.63 per barrel (or 11 cents per gallon), are used. Assuming a yield of 22 gallons (two-thirds of a barrel) of sirup per ton of cane, the cost per ton for making the cane into sirup is calculated at two-thirds of $3.63, or $2.42.

TABLE II.—*Summary of assumed yields of cane and cost of sirup production.*

| Cane crop. | Computation based on tonnage yield of cane per acre. | | | Computation based on sirup production from an acre of cane. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Yield. | Cost of— | | Yield. | Cost of— | | Yield. | Cost of— | |
| | | Cane at mill, per ton. | Sirup from ton of cane. | | Cane at mill, per barrel of sirup. | Sirup, per barrel. | | Cane at mill, per gallon of sirup. | Sirup, per gallon. |
| | *Tons.* | | | *Barrels.* | | | *Gallons.* | *Cents.* | *Cents.* |
| Plant cane | 22 | $2.45 | $5.09 | 15 | $3.60 | $7.56 | 495 | 11 | 23 |
| First-year stubble | 15 | 2.20 | 4.84 | 10 | 3.30 | 7.26 | 330 | 10 | 22 |
| Second-year stubble | 11 | 2.80 | 5.44 | 7.3 | 4.25 | 8.21 | 240 | 12 | 24 |

The varying degrees of remuneration or profit per acre which will accrue to the manager (who is ordinarily the owner) in return for his time, at different prices for sirup, are shown in Table III.

TABLE III.—*Remuneration or profit per acre to the manager or owner.*

| Crop. | Profit per acre when the price of sirup per gallon is— | | | |
|---|---|---|---|---|
| | 23 cents. | 25 cents. | 30 cents. | 40 cents. |
| Plant cane | 0 | $9.90 | $34.65 | $84.15 |
| First-year stubble | $3.30 | 9.90 | 26.40 | 59.40 |
| Second-year stubble | [1] −2.40 | 2.40 | 14.40 | 38.40 |

[1] No remuneration; crop produced at a loss.

Table III shows that under the favorable conditions assumed in these calculations and with normal seasonal conditions the price for sirup in bulk must be above 23 cents a gallon to afford any remuneration or profit to the owner or manager. In actual practice the conditions average less favorably, as is shown by the fact that the average yields of cane, as given in census reports, are far below the above-assumed normals. This may be due to a variety of causes, such as poor soil, unfavorable seasonal conditions, and poor management.

It is not assumed that the conditions shown by the calculations here used fit the case of other farmers without some modifications, or even of the same farmers for other years. The figures, however, have here been set forth in such detail that it should be easy for any farmer to make a similar calculation as to the cost of production on his farm. He may have more expensive land and will have to compute higher rental; he may be able to get along with less fertilizer; he may be able to use his labor more efficiently with better implements or otherwise; he may get smaller yields or perchance larger ones, etc. He can substitute figures fitting his conditions and compute the cost to him of the production of the cane or the sirup. Thus the Florida farmer previously mentioned who estimated the cost of the plant-cane crop at $69 an acre will find that his sirup from this crop costs him $8.56 per barrel (or 26 cents per gallon) if the yield and the manufacturing expense are the same. In the case of the second illustration of the cost of cane production, if the farmer could by a different rotation, plowing under a leguminous crop or otherwise, reduce his fertilizer bill by half without reducing his yields, it would increase his profit per acre $10, reducing the cost of sirup by 67 cents per barrel, or 2 cents per gallon. The fuel item is bound to increase as timber gets scarcer unless means are provided for using a cheaper grade of fuel (dead and down timber, slab wood, or coal if near the railway). If varieties or methods of treatment could be discovered that would enable the farmer to increase the yields of his stubble crops or allow him to take off more stubble crops with high yields before replanting, the profits per acre would be greatly increased. Table II shows that the higher the price of sirup the greater is the advantage in profit per acre of the plant-cane crop over the stubble crops, provided our assumption that the yield of the first-year stubble crop is only two-thirds and the second-year stubble crop only half that of the plant-cane crop corresponds to the facts.

The price of sirup in the general market in recent years has ranged from 28 to 35 cents per gallon. In the fall of 1914 the price was abnormally low, leading many farmers to go out of the business or to reduce their acreage. In the fall of 1915 it took a sharp upward trend, reaching 40 cents, or even more. This was when sugar also was abnormally high, but it was due mainly to the abnormally short crop. This shortage in turn was due to two causes: (1) Severe droughts in the principal sirup-producing sections and (2) a small acreage, which, in its turn, was due to low prices the previous year and to much spoilage of seed cane reserved for planting. In many sections the local demand for sirup exceeds the supply. In such cases the sirup producers usually get a much better price, viz, from 35 to 50 cents a gallon—even higher if they have the reputation of making a product of extra good quality.

By present practices the farmer's income from the sugar-cane sirup industry is confined almost exclusively to the sales of the cane or the sirup therefrom. It is but natural that he thinks of higher prices for the product as the main hope, if not the only chance, of increasing his profits. As the price of the product, however, may be beyond his control, he is forced to turn to the cost of production and to the individual factors contributing thereto for possible opportunities to increase the profits. There is yet another phase of the industry that merits consideration while striving to increase profits, viz, the utilization of by-products.

## UTILIZATION OF BY-PRODUCTS.

There are three by-products: (1) The leaves and tops, (2) the bagasse (pomace, or mash), and (3) the skimmings, all three of which are almost completely wasted under present practices.

The leaves and tops, removed from the cane at harvesting, are usually allowed to remain in the field until they become dry and are then burned. The production of tops per acre, if weighed fresh, is 3 to 4 tons. To a small extent they afford pasturage to stock, but as a rule they soon become weathered and worthless for feed. Some attempts have been made at curing the tops to feed in the winter, but the weather conditions are usually unfavorable unless the farmer has shelter in which to cure them. A more hopeful method of preserving them is by making ensilage of them. (Fig. 18.) At the experiment field at Cairo, Ga., experiments were conducted during the last two years which indicate that siloing for feed is an excellent way to utilize the tops. The cattle took the silage readily and thrived on it. The chemical analysis showed it to be but little inferior to silage from whole corn in nutritive value. A characteristic sample upon analysis gave percentages as follows: Moisture, 75; ash, 1.71; crude protein, 1.93; crude fiber, 9.23; ether extract, 0.47; nitrogen-free extract, 11.66. The acidity, normal alkali per kilo, was 124 c. c. The shortage of available roughage for winter feeding in the cane-sirup sections makes this silage more valuable than its chemical composition would indicate. To assure good silage from the cane tops the silo should be filled before the cane is frosted. In

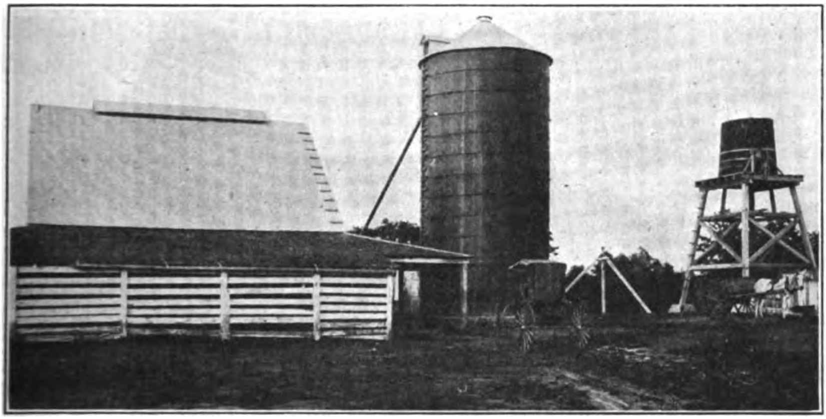

FIG. 18.—A silo in Louisiana built especially for sugar-cane tops.

filling it, as in filling with other forage, it is essential to tramp it in the silo very thoroughly, not only in the middle but near the walls as well. The importance of thus compacting it is not generally appreciated by those not familiar with making ensilage.

From these experiments it is evident that the main question with the farmer in this method of utilizing the tops is no longer whether it makes good feed, but rather whether he has the labor and teams available at the time to collect and haul the tops and to fill the silo. It was found in these experiments to require only an insignificant amount of extra time on the part of the toppers to throw the tops into heaps, 8 to 10 feet apart, while they top the cane. The work of collecting the tops and filling the silo is therefore the main consideration. Important additional value comes from the manure resulting from feeding these tops. In these same localities, where the systems of farming in vogue tend so strongly to deplete the soil of its humus content, the manure has unusually high value.

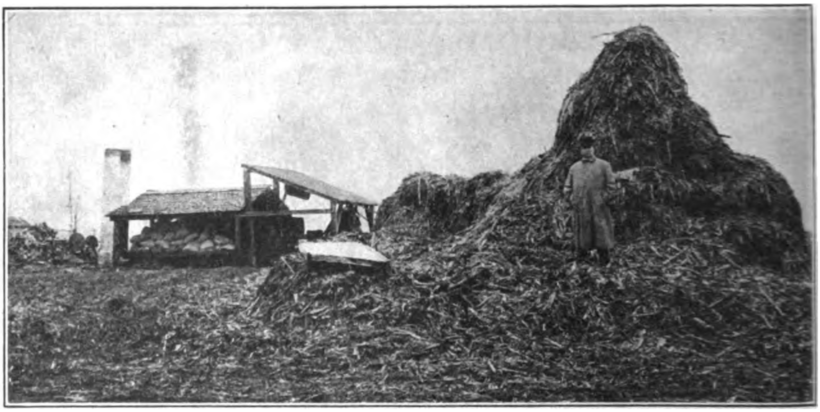

FIG. 19.—A pile of bagasse, or pomace, after sirup-making time.

The bagasse, or pomace, accumulates in vast heaps at the sirup mills and at present finds but little use. (Fig. 19.) Some farmers even go to the expense of hauling it off to waste woodland areas without getting any use from it. These small mills effect too incomplete an extraction of the juice to admit of using the bagasse as fuel, as is done in the big sugar factories. The most profitable disposition of it now being made is to use it in large quantities as litter to mix with the barnyard manure, and when rotted for about a year in this form to apply it to sweet-potato land or to land for some other crop not injured by fresh applications of manure. As a result of the low extraction of the juice by small horsepower or gasoline-power farm mills, which recover only 50 to 60 per cent of the 88 to 90 per cent of juice present, the bagasse has a feeding value while fresh that is not insignificant, especially where roughage is at a premium. While fresh, stock will eat it readily, but it soon sours when exposed. If it were dried without loss, its chemical composition should indicate a feeding value about equal to that of oat straw. Drying it artificially is undoubtedly too expensive for such a low-grade product. Making ensilage of it is suggested, but it yet remains to be determined whether the slight unavoidable fermentation in the silo would too nearly exhaust it of its remaining nutrients to make a palatable ensilage. In a single test made at the experiment field at Cairo, Ga., the results were encouraging, but the product was abnormally sour, probably owing to insufficient tramping and to the fact that the cane was badly frostbitten before grinding. Fermentation had proceeded so far that the bagasse was thoroughly infected with the acid-forming microorganisms before it was put into the silo. For making ensilage the bagasse has the advantage that it would involve practically no extra expense for collecting and hauling, assuming that the silo is not far from the mill. To pack well in the silo, some water must be supplied while filling. If no better use can be made of the bagasse, it should be heaped in a manner to facilitate rotting, and after one or two years, when sufficiently rotted, applied to land where humus is needed.

The skimmings on most farms are wasted. Some sirup makers allow them to settle over night, or for a half day, then draw off the clear, slightly sour juice between the sediment and the floating scum and boil it back into the sirup. There is danger of injuring the flavor of the sirup by this practice, especially if the containers for the skimmings are not kept thoroughly clean or sterilized. It was found in the experiments at Cairo, Ga., that sheet-iron vessels, e. g., ash cans, if used to collect skimmings, can readily be rinsed out each morning sufficiently clean so that fermentation would start but slowly after refilling with skimmings. It was thus possible to hold the skimmings, even in moderately warm weather, as long as 24 hours without serious souring, thus affording ample time to effect good settling. By providing suitable tap holes about 1½ inches from the bottom of each such container, the clear juice from the preceding day's boiling could each morning be drawn off and boiled with fresh juice to make sirup. Wooden containers can not be cleaned so satisfactorily and in them fermentation starts more rapidly. Some farmers feed all the skimmings while fresh to hogs, which is a good way of utilizing them where feasible, but less profitable than to save the cleared portion for sirup making. One farmer near Cairo, Ga., utilizes them by boiling them down to a thick, molasseslike feed, which keeps indefinitely and is greatly relished by his stock at any time of year. Where a silo is being filled while boiling sirup, a good utilization of the skimmings might be to work them in with the silage while fresh.

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**BULLETIN No. 487**
Contribution from the States Relations Service
A. C. TRUE, Director

Washington, D. C. PROFESSIONAL PAPER January 25, 1917

# JUDGING HORSES AS A SUBJECT OF INSTRUCTION IN SECONDARY SCHOOLS

By

**H. P. BARROWS, Assistant in Agricultural Education,**
**States Relations Service**

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## INTRODUCTION.

A study of types and breeds of horses is considered an essential part of the general course in animal husbandry in secondary schools. Considerable attention and interest are centered around the scoring and judging of horses in connection with the study. It is the aim of this bulletin to give such specific instructions as will aid in making this work more practical.

The subject matter which follows is not original. Leading authorities have been consulted freely.

## TEACHING THE JUDGING OF HORSES.

*Value and place of the subject in the curriculum.*—Practical work in stock judging has done much to arouse interest and enthusiasm in animal husbandry on the part of the student. It has also done a great deal toward allaying prejudice and developing sympathy among those who looked upon the teaching of agriculture as "book farming." Judging horses in connection with a study of types and breeds is an essential foundation work for a study of breeding, feeding, training, and general management of horses which should follow in the course.

---

[1] Prepared under the direction of C. H. Lane, Chief Specialist in Agricultural Education.

NOTE.—This bulletin is intended for the use of teachers of secondary agriculture.

It is not likely that all members of any class will develop into experts in horse judging. Only a comparative few may have the inherited talents, which with years of training will rank them as masters in the prize ring. It is not the aim of the high-school course to develop specialists. It should strive, however, to give such instruction as will create a greater interest in the subject and such training as may be applied with profit in buying and selling horses for the farm.

*Common method of training.*—Boys who have an inborn love for and interest in horses take notice of each horse they see, intuitively making comparisons and estimates of values. Such boys are fortunate indeed if they have the privilege of associating with men who know horses well, and the opportunity of attending fairs and visiting other places where good individuals may be seen. Careful observation with large numbers has resulted in remarkable ability on the part of some of these enthusiasts, which has been of great value in making comparisons in the show ring and in estimating values at sales. School work in judging will not take the place of general observation and constant practice, but should supplement it and inspire it in the case of those who may lack interest.

*Classroom instruction v. practice.*—Although stock judging is essentially an art to be learned by practice, under supervision, it is based upon scientific principles which should be given careful study. A discussion of the principles underlying the judging of draft horses should be taken up in the classroom before practical judging begins. The ideals of to-day are the types of to-morrow, hence the importance of establishing in the minds of future judges sound ideals based upon scientific principles. A discussion of principles and points arising in practice may be profitable in the presence of the animal judged, but as a matter of convenience such discussion is often deferred until the next classroom meeting.

*Use of illustrative material.*—The teacher should keep in mind that the student learns largely through what he sees. In establishing ideals of animal types nothing has value equal to living specimens which approach perfection. Inasmuch as horses which approach ideal types are not common nor convenient to keep before the students, the teacher should make use of an abundance of illustrative material. Pictures of prize winners appear from time to time in all good live-stock journals. (Fig. 1.) If files are not kept of these papers the good pictures should be clipped and mounted upon cards for classroom use. A projection lantern with an opaque attachment will be found invaluable in this work.[1]

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[1] Lantern slides illustrating types and breeds of horses, including the illustrations of this bulletin, may be obtained from the office of Agricultural Instruction of the States Relations Service. Charts and stencils for use on blackboards may be made by tracing the outline of a diagram thrown on paper by a lantern.

## CLASSROOM DISCUSSION.

*The horse as a machine.*—All farm animals may be considered as machines which have definite work to do. We may look upon the horse as a mechanism which converts raw material in the form of forage and grain into work. In other words, the latent energy in the food is made to do work by means of the living mechanism we call a horse. A machine has value according to its efficiency in doing work. Before we can estimate the efficiency of this particular machine we must know something about its structure in relation to the work it has to do.

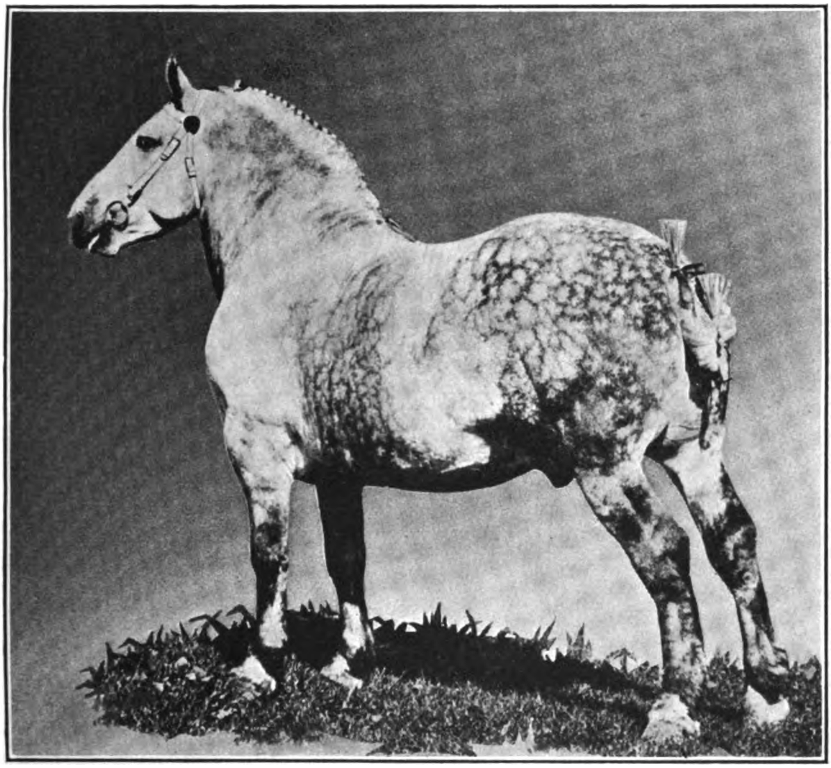

FIG. 1.—A good draft horse.

*Anatomy as a basis for study.*—We may consider the horse as a mechanism in which latent energy in food is made active in muscles which work upon bones as levers, the operation being stimulated and controlled by the nervous system. It may be necessary to review at this time the fundamentals of physiology which have to do with the use of food. Charts showing the skeleton of a horse and the relation of muscles to bones will prove almost indispensable in giving a clear understanding of the anatomy of the horse. (Fig. 2.) The different classes of levers should be demonstrated to the class, after which the students may point out the application of the physical principles involved in the movements of the horse. It is important to consider the relative lengths of bones and muscles in their relation to strength and the transmission of power. The manner of attachment of muscles to bones should be emphasized also in relation to its effect upon the power to do work. Throughout the discussion a comparison of the structure underlying speed should be made with that form associated with strength. The charts should aid the students in understanding the extent to which the form of a horse depends upon the skeleton and to what extent the muscles contribute to form. The structure of bones and muscles do not determine altogether the working of the

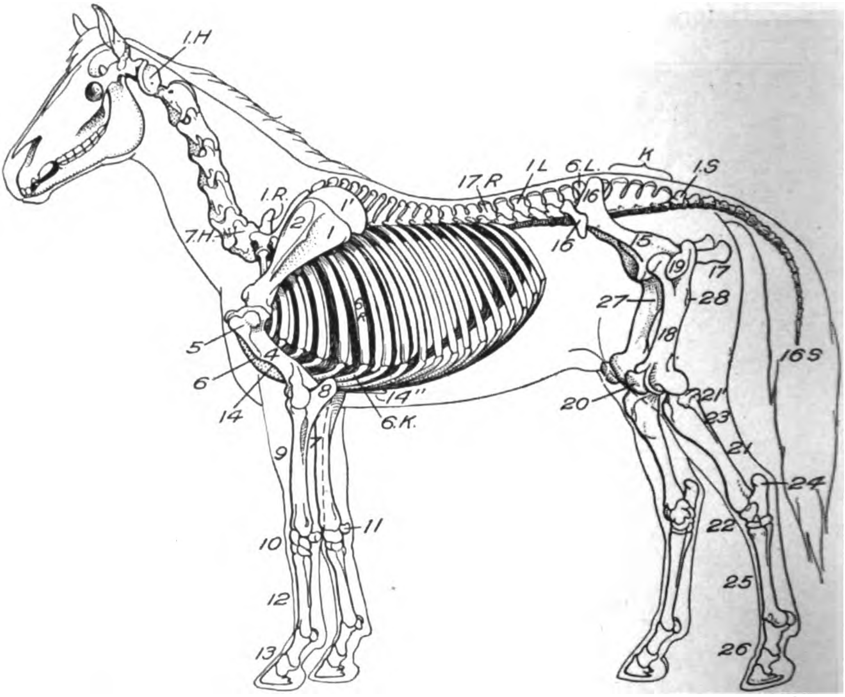

FIG. 2.—Skeleton of horse with outline of contour of body. (From Sisson, The Anatomy of the Domestic Animals.) 1 H, Atlas; 7 H, seventh cervical vertebra; 1 R, first thoracic vertebra; 17 R, seventeenth thoracic vertebra; 1 L, first lumbar vertebra; 6 L, sixth lumbar vertebra; K, sacrum; 1 S, first coccygeal vertebra; 16 S, sixteenth coccygeal vertebra; 6 R, sixth rib; 6 K, costal cartilage: 1, scapula; 1', cartilage of scapula; 2, spine of scapula; 4, humerus; 5, lateral tuberosity of humerus; 6, deltoid tuberosity; 7, shaft of ulna; 8, olecranon; 9, radius; 10, carpus; 11, accessory carpal bone; 12, metacarpus; 13, digit; 14, sternum; 14", xiphoid cartilage; 15, ilium; 16, 16, angles of ilium; 17, ischium; 18, femur (shaft); 19, trochanter major; 20, patella; 21, tibia (shaft); 21', lateral condyle of tibia; 22, tarsus; 23, fibula; 24, tuber calsis; 25, metatarsus; 26, digit; 27, trochanter minor of femur; 28, trochanter tertius of femur.
(After Ellenberger-Baum, Anat. für Kunstler.)

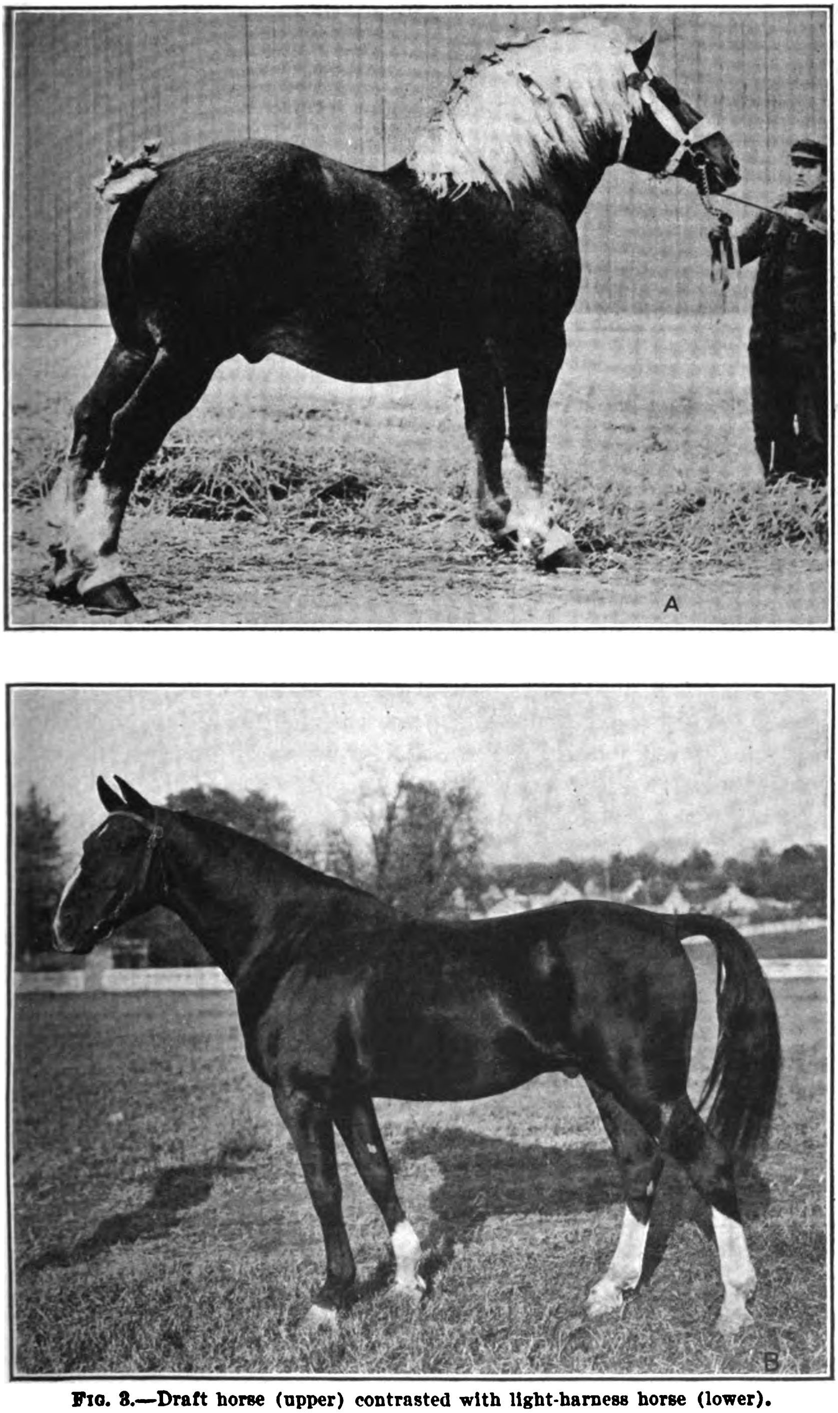

**FIG. 3.—Draft horse (upper) contrasted with light-harness horse (lower).**

machine. Much depends upon the nervous organization of the animal. The relation of this organization to temperament may be made clear at this time.

*Classification of horses.*—The breeds of horses may be grouped according to the work required of them. Such a classification gives us light-harness horses, heavy harness or coach horses, saddle horses, draft horses, and ponies.[1]

Other classifications may be used in the show ring and market. While smaller horses may be used on the farm and for other work which requires heavy pulling, an animal is not considered a draft horse unless it weighs over 1,500 pounds. (Fig. 3.)

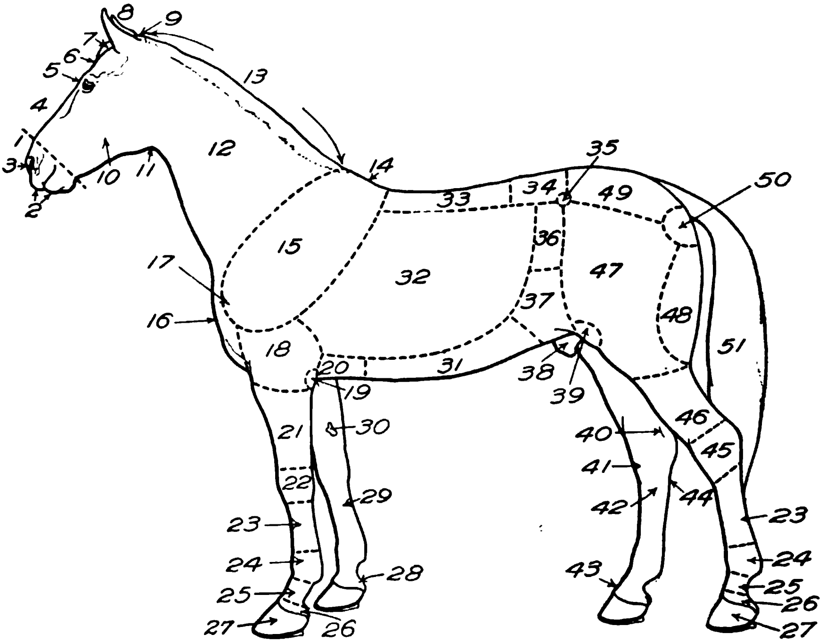

FIG. 4.—Regions of the horse: 1, Muzzle; 2, lips; 3, nostril; 4, face; 5, eye; 6, forehead; 7, foretop; 8, ears; 9, poll; 10, jaw; 11, throatlatch; 12, neck; 13, crest; 14, withers; 15, shoulder; 16, breast; 17, point of shoulder; 18, arm; 19, elbow; 20, fore flank; 21, forearm; 22, knee; 23, cannon; 24, fetlock joint; 25, pastern; 26, coronet; 27, feet; 28, seat of side bone; 29, seat of splint; 30, chestnut; 31, abdomen; 32, ribs; 33, back; 34, loin; 35, point of hip; 36, coupling; 37, hind flank; 38, sheath; 39, stifle joint; 40, seat of thoropin; 41, seat of bog spavin; 42, seat of bone spavin; 43, seat of ring bone; 44, seat of curb; 45, hock; 46, gaskin; 47, thigh; 48, quarter; 49, group; 50, point of buttock; 51, tail.

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[1] The draft horse is chosen as a type to illustrate methods of teaching because of its importance in connection with farming. As the light-harness horse is also important in all rural communities, a score card and descriptive matter pertaining to that type is given. Methods of teaching are much the same for all types of horses. In some districts the heavy harness and saddle horses may be important enough to give special consideration. Score cards and descriptive matter pertaining to these types will be found in the general references given.

*The modern draft horse.*—The modern draft horse is the result of a demand for great power in hauling heavy loads. This power is associated with weight and has been gained at a sacrifice of speed. While the breeding of draft horses is increasing in the United States, this country has received all of its draft breeds from Europe and is still importing a great many of its breeding animals. All of the draft breeds have distinctive breed characteristics which may be considered by the class after a general consideration of type. All draft breeds conform to the type to be considered.[1]

*Terms used in judging.*—Before proceeding with a study of the draft type, the student should learn the names of the parts of a horse. It is not wise to assume that the high-school students knows all the terms used in judging. (Fig. 4.) An outline drawing may be used to designate the names of the parts. If drawn upon the blackboard the names of the parts may be erased and the students asked to fill them in.

*The score card.*—Some time may be used by the students in the classroom in becoming familiar with the score card which they are to use. They should understand that the score card is a detailed description of a perfect animal designed to aid them in establishing an ideal. The card will also aid them in examining an animal in a systematic manner and give them a sense of relative values in judging. Many different score cards for draft horses have been devised. Variation in score cards is likely to continue, as there will always be a difference of opinion upon the relative value of minor points and upon forms of grouping. The forms given here are used by the Iowa State College. Similar forms are used in a number of other schools.[2]

*Students' score card.*

DRAFT HORSES.

| Scale of points for gelding. | Perfect score. | Students' score. | Corrected score. |
|---|---|---|---|
| 1. Age | .......... | .......... | .......... |
| General appearance—16 points: | | | |
| 2. Height | .......... | .......... | .......... |
| 3. Weight, over 1,750 pounds. Score according to age | 4 | .......... | .......... |
| 4. Form, broad, massive, low set, proportioned | 4 | .......... | .......... |
| 5. Quality, bone clean, yet indicating sufficient substance; tendons distinct, skin and hair fine | 4 | .......... | .......... |
| 6. Temperament, energetic, good disposition | 4 | .......... | .......... |
| Head and neck—6 points: | | | |
| 7. Head, lean, medium size | 1 | .......... | .......... |
| 8. Muzzle, fine, nostrils large; lips thin, even | 1 | .......... | .......... |
| 9. Eyes, full, bright, clear, large | 1 | .......... | .......... |
| 10. Forehead, broad, full | 1 | .......... | .......... |
| 11. Ears, medium size, well carried | 1 | .......... | .......... |
| 12. Neck, muscled; crest high; throat latch fine; windpipe large | 1 | .......... | .......... |

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[1] For a description of breeds see Breeds of Draft Horses, U. S. Dept. Agr., Farmers' Bul. 619 (1914).

[2] Score cards may be obtained from most of the State agricultural colleges.

*Students' score card*—Continued.

### DRAFT HORSES—Continued.

| Scale of points for gelding. | Perfect score. | Students' score. | Corrected score. |
|---|---|---|---|
| Forequarters—25 points: | | | |
| 13. Shoulders, sloping, smooth, snug, extending into back | 2 | | |
| 14. Arm, short, thrown forward | 1 | | |
| 15. Forearm, heavily muscled, long, wide | 2 | | |
| 16. Knees, wide, clean cut, straight, deep, strongly supported | 2 | | |
| 17. Cannons, short, lean, wide; sinews large, set back | 2 | | |
| 18. Fetlocks, wide, straight, strong | 1 | | |
| 19. Pasterns, sloping, lengthy, strong | 3 | | |
| 20. Feet, large, even size, straight; horn dense, dark color; sole concave; bars strong; frog large, elastic; heel wide, high, one-half length of toe | 8 | | |
| 21. Legs, viewed in front a perpendicular line from the point of the shoulders should fall upon the center of the knee, cannon, pastern, and foot; from the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and back of hoof | 4 | | |
| Body—9 points: | | | |
| 22. Chest, deep, wide, low; large girth | 2 | | |
| 23. Ribs, long, close, sprung | 2 | | |
| 24. Back, straight, short, broad | 2 | | |
| 25. Loin, wide, short, thick, straight | 2 | | |
| 26. Underline, flank low | 1 | | |
| Hindquarters—34 points: | | | |
| 27. Hips, smooth, wide | 2 | | |
| 28. Croup, long, wide, muscular | 2 | | |
| 29. Tail, attached high, well carried | 1 | | |
| 30. Quarters, deep, heavily muscled | 3 | | |
| 31. Gaskins or lower thighs, wide muscled | 2 | | |
| 32. Hocks, clean cut, wide, straight | 8 | | |
| 33. Cannons, short, wide; sinews large, set back | 2 | | |
| 34. Fetlocks, wide, straight, strong | 1 | | |
| 35. Pasterns, sloping, strong, lengthy | 3 | | |
| 36. Feet, large, even size, straight; horn dense, dark color; sole concave; bars strong; frog large, elastic; heel wide, high, one-half length of toe | 4 | | |
| 37. Legs, viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern, and foot; from the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle, and a perpendicular line from the point of the buttock should run parallel with the line of the cannon | 6 | | |
| Action—10 points: | | | |
| 38. Walk, smooth, quick, long, balanced | 6 | | |
| 39. Trot, rapid, straight, regular | 4 | | |
| Total | 100 | | |

### LIGHT HORSES.

| Scale of points for gelding. | Perfect score. | Students' score. | Corrected score. |
|---|---|---|---|
| 1. Age | | | |
| General appearance—12 points: | | | |
| 2. Weight | | | |
| 3. Height | | | |
| 4. Form, symmetrical, smooth, stylish | 4 | | |
| 5. Quality, bone clean, fine, yet indicating sufficient substance; tendons defined, hair and skin fine | 4 | | |
| 6. Temperament, active, good disposition | 4 | | |
| Head and neck—6 points: | | | |
| 7. Head, lean, straight | 1 | | |
| 8. Muzzle, fine, nostrils large, lips thin, even | 1 | | |
| 9. Eyes, full, bright, clear, large | 1 | | |
| 10. Forehead, broad, full | 1 | | |
| 11. Ears, medium size, pointed, well carried, and not far apart | 1 | | |
| 12. Neck, muscled; crest high; throat latch fine; windpipe large | 1 | | |
| Forequarters—23 points: | | | |
| 13. Shoulders, long, smooth, with muscle; oblique, extending into back and muscled at withers | 2 | | |
| 14. Arm, short, thrown forward | 1 | | |
| 15. Forearm, muscled, long, wide | 2 | | |
| 16. Knees, clean, wide, straight, deep, strongly supported | 2 | | |

*Students' score card*—Continued.

LIGHT HORSES—Continued.

| Scale of points for gelding. | Perfect score. | Students' score. | Corrected score. |
|---|---|---|---|
| **Forequarters**—23 points—Continued. | | | |
| 17. Cannons, short, wide; sinews large, set back | 2 | .......... | .......... |
| 18. Fetlocks, wide, straight | 1 | .......... | .......... |
| 19. Pasterns, strong, angle with ground 45° | 3 | .......... | .......... |
| 20. Feet, medium, even size, straight; horn dense; frog large, elastic; bars strong; sole concave; heel wide, high | 6 | .......... | .......... |
| 21. Legs, viewed in front a perpendicular line from the point of the shoulders should fall upon the center of the knee, cannon, pastern, and foot. From the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and back of hoof | 4 | .......... | .......... |
| **Body**—9 points: | | | |
| 22. Chest, deep, low, large girth | 2 | .......... | .......... |
| 23. Ribs, long, sprung, close | 2 | .......... | .......... |
| 24. Back, straight, short, broad, muscled | 2 | .......... | .......... |
| 25. Loin, wide, short, thick | 2 | .......... | .......... |
| 26. Underline, long; flank let down | 1 | .......... | .......... |
| **Hindquarters**—30 points: | | | |
| 27. Hips, smooth, wide, level | 1 | .......... | .......... |
| 28. Croup, long, wide, muscular | 2 | .......... | .......... |
| 29. Tail attached high, well carried | 1 | .......... | .......... |
| 30. Thighs, long, muscular, spread, open angled | 2 | .......... | .......... |
| 31. Quarters, heavily muscled, deep | 2 | .......... | .......... |
| 32. Gaskins or lower thighs, long, wide, muscular | 2 | .......... | .......... |
| 33. Hocks, clearly defined; wide, straight | 7 | .......... | .......... |
| 34. Cannons, short, wide; sinews large, set back | 2 | .......... | .......... |
| 35. Fetlocks, wide, straight | 1 | .......... | .......... |
| 36. Pasterns, strong, sloping | 2 | .......... | .......... |
| 37. Feet, medium, even size; straight; horn dense; frog large, elastic; bars strong; sole concave; heel wide, high | 4 | .......... | .......... |
| 38. Legs, viewed from behind a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern, and foot. From the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle; and a perpendicular line from the point of the buttock should run parallel with the line of the cannon | 4 | | |
| **Action**—20 points: | | | |
| 39. Walk, elastic, quick, balanced | 5 | .......... | .......... |
| 40. Trot, rapid, straight, regular, high | 15 | .......... | .......... |
| Total | 100 | .......... | .......... |

## PRACTICE JUDGING.

*Preparing for a judging trip.*—Exercises in stock judging, like other field trips, are often failures because proper preparation is not made for them. The teacher should know beforehand where he is going and what he is going to do. If possible, the animal chosen for the first lesson should approach the perfect draft type, as it will aid in fixing the ideal in the minds of the students. Horses should be selected which may be easily handled, especially for the first trip. Arrangements should be made with the owner so that the horse will be ready, and in order that there will be no misunderstanding upon taking the class to his premises. It may be possible to have the horse brought to the school; if this may be arranged it will save a good deal of time for the class. It is difficult to judge a horse properly without plenty of room. Wet, muddy barnyards should be avoided. The instructor will find it to his advantage to go over the animal he intends to use in a thorough manner before the class judges it. When comparative judging is practiced it is especially important that the teacher know the animals and their relative merits well.

If students have had no experience in judging horses it will be well to use the first judging period in learning how to approach the animal, in checking up what they have learned about naming the parts, and in going over the card with the instructor. If the class has been studying light horses the first period may be spent in comparing a draft animal with a light-harness horse.

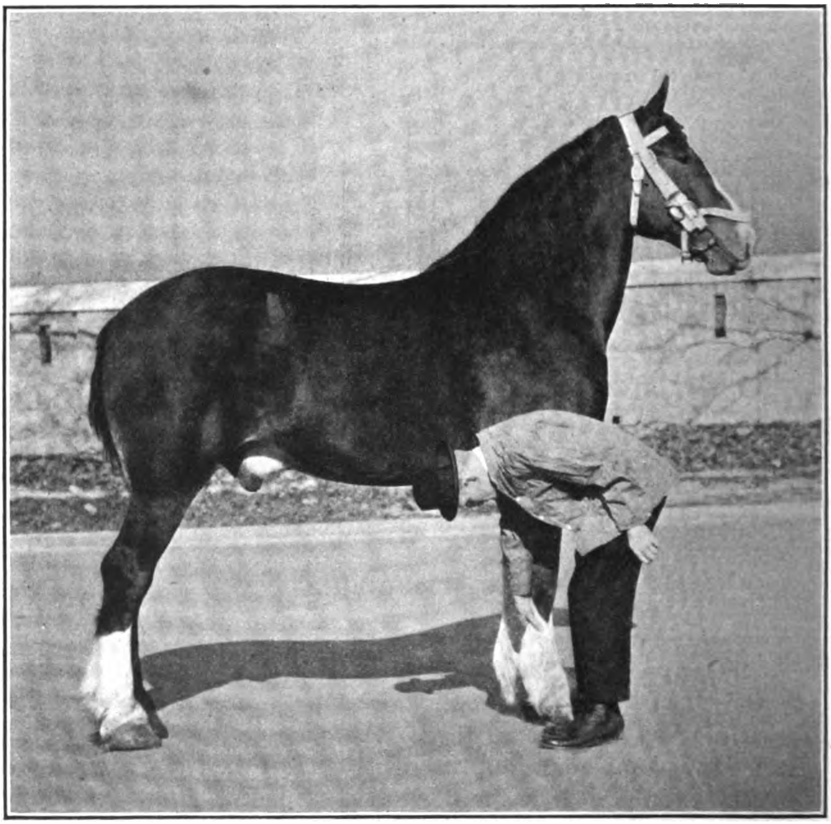

FIG. 5.—Student feeling legs of a horse to determine quality.

*How to examine a horse.*—The horse should be led out to a well-lighted place where there is plenty of room for the students to walk all around it at some distance. In judging horses the eye is the chief factor in determining values, the hand being used merely to assist the eye. (Fig. 5.) Students will need to use their hands at first, especially in determining quality as relating to the coat and in detecting unsoundness. After some experience the eye will reveal much that required the use of the hand at first. The value of accurate first impressions should be emphasized. If the student has an ideal draft horse in mind he will be impressed at once as to whether the animal before him conforms to that type or not. His first impression will determine largely his judgment as to the score given under general appearance. Whether the student judges the action of the horse before making a detailed examination will depend upon the score card used. In some cards action is included under general appearance.

*Using the score card.*—After the students have become familiar with the card and the method of approaching the animal they may make individual scores. Each student should work independently. Conversation and comparison of scores should be avoided while the work is being done. The teacher should use his judgment in determining whether his time may be spent better in aiding the students or in scoring the animal as a basis for checking upon their results. One of the chief purposes in using a score card is to train the student in observation, so no details should be overlooked. The card will give the score for perfection in the various parts. The student will enter a score which represents the amount which he judges the animal to be deficient. The sum of these deficient amounts subtracted from 100 gives the score of the animal. As a rule no defect should result in a cut to exceed half of the total number of points allowed for the part under consideration. A cut should not be made for less than one-fourth of a point.

The following is a more detailed consideration of the scoring of the animal:

## DRAFT HORSES.

### GENERAL APPEARANCE.

*Height.*—The height of a horse is measured in hands (a hand is four inches), the measurement being made from the top of the withers to the ground. (Fig. 6.) The ideal draft horse should be over 16 hands and under 17½ hands in height. It is desirable that the students acquire accuracy in estimating the height as well as the weight of a horse. At first a hand stick, or hippometer, a measuring staff marked off in hands, will be found useful.

*Weight.*—Draft horses may be divided into three classes according to weight. Light draft, 1,500 to 1,600 pounds; medium draft, 1,600 to 1,800 pounds; and heavy draft, 1,800 pounds and over. The importance of weight should be emphasized. Other qualities being equal, the heavier horse can draw the heavier load. Not only will the extra weight be brought against the load, but it will also give the heavy horse a firmer footing by increasing the friction between the shoe and the hard pavement. Students should make individual estimates of the weight of the horse, and the teacher should have these estimated weights corrected by comparison with the weight as shown upon accurate scales.

*Form.*—A broad, massive, low-set form will bring the center of gravity near the base of support and thus make the equilibrium of the horse more stable. The general form is due to the legs as well as the body, so the body and legs should be well proportioned. To take in the form well the students should note the horse carefully from the front, the rear, and both sides at some distance. (Fig. 7.)

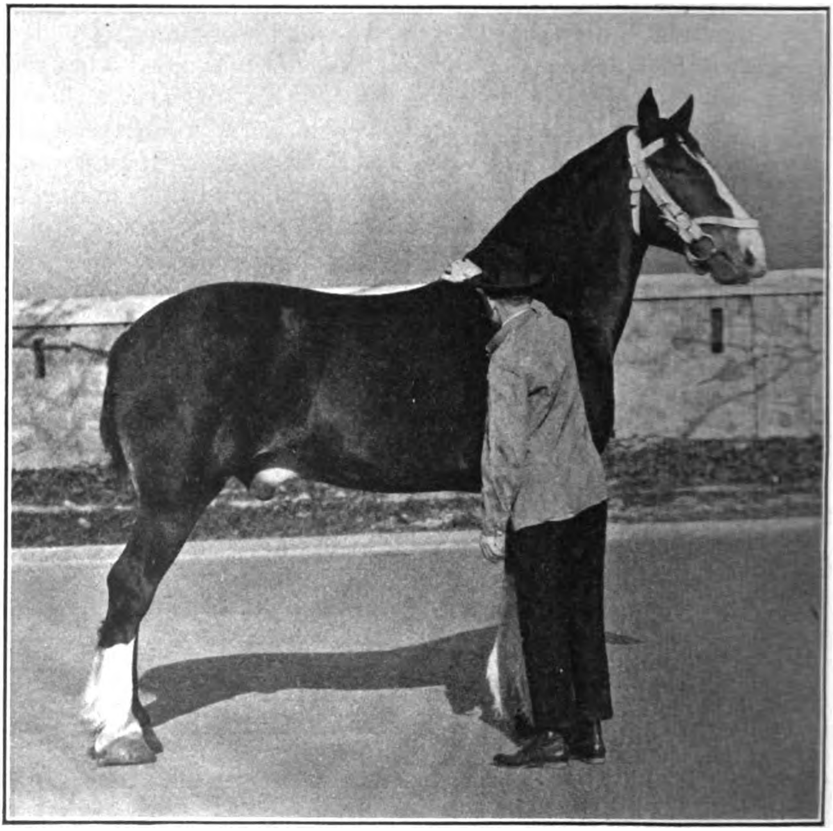

FIG. 6.—Student estimating the height of a horse.

*Quality.*—Quality is a rather comprehensive term, difficult to define, although it is understood by all judges of live stock. It has reference to evidence of refinement as opposed to coarseness. There is a correlation between the exterior of a horse and its internal anatomy. A pliable skin, with soft silky hair is evidence of health and the normal functioning of internal organs. Such skin and hair is associated with well-defined tendons; smooth, well-developed, muscles; strong, smooth bone; clean, well-defined joints; and dense, sound hoofs. Quality is often associated with style, spirit, and speed.

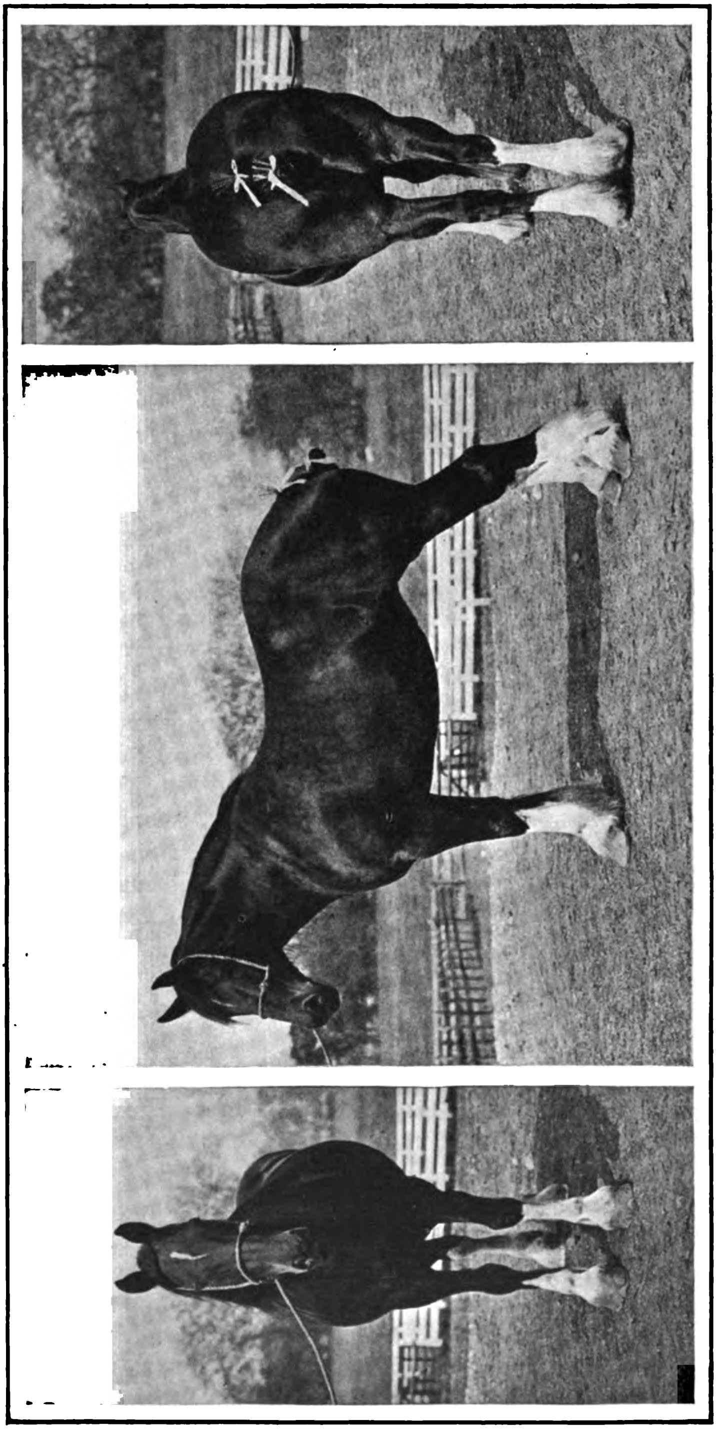

Fig. 7.—Front, side, and rear views of draft horse.

While one can not expect the highest quality in draft horses, there should not be a tendency toward undue coarseness which would indicate weakness. As extra weight is likely to be associated with coarseness, and as the combination of weight and quality is especially desirable, special attention should be paid to the quality of extra large horses. The students should look to quality as shown in the legs. The cannon bone especially should be clean, with a well-defined tendon behind. In the case of the breeds which have long hair, or "feather," upon the lower leg and coronet the fineness of the hair is given considerable attention as an indication of the quality of bone and hoof.

*Temperament.*—While the draft horse should be lively, energetic, and vigorous, he should be of a docile disposition, manageable at all times, and give evidence of intelligence. Excessive nervousness as well as a sluggish temperament should result in a cut in the score. The student should be observant of bad habits and vices and make deductions for them under temperament.

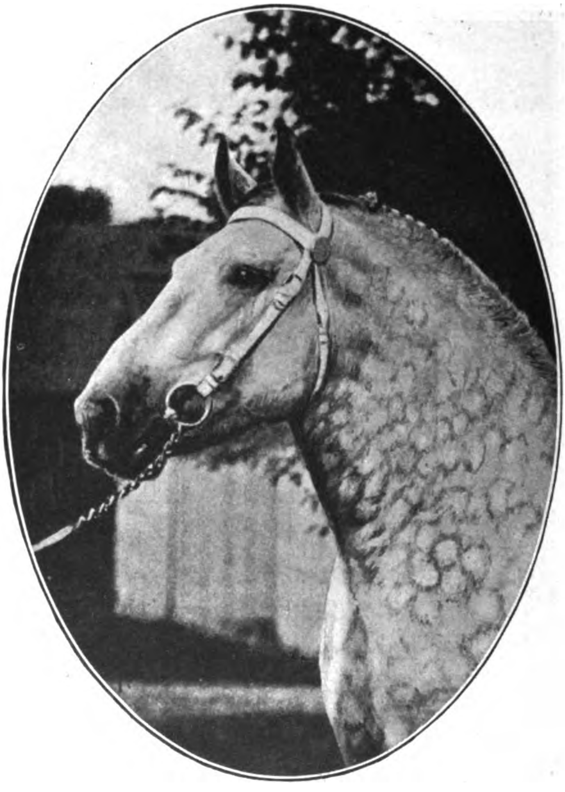

FIG. 8.—A good head.

### HEAD AND NECK.

*Head.*—The head should be proportionate to the body in size. It should show character and have a pleasing appearance. (Fig. 8.) There should be freedom from excessive flesh, coarseness, and irregularities. The appearance of the horse depends much upon the manner in which the head is carried.

*Muzzle.*—The muzzle should be large, the lips thin, and well controlled, covering teeth which meet evenly. Large flexible nostrils indicate good breathing power. There should be a healthy pink color to the lining of the nostrils and an absence of ulcers or a bad odor which might indicate disease.

*Eyes.*—The eyes should be full, bright, large, and mild and should be free from cloudiness, specks, and white spots.

*Forehead.*—The forehead should be broad and full, neither dished nor too prominent. Good width between the eyes indicates intelligence. While there is a tendency toward the Roman nose in some breeds, the straight-face profile is preferred.

*Ears.*—The ears are listed upon the card as medium in size, which means that they should be in proportion to the size of the horse, not too small, not too large. They should show good quality, should be soft and pliable, free from coarseness, being active and alert.

*Neck.*—While the neck should give evidence of strength, it should be free from thickness and coarseness. It should fit neatly into the head at one end and into the withers and the shoulders. The crest should be high, i. e., the neck should be arched well, with no tendency toward a "ewe neck," which term is applied to a neck too bulging and thick along the lower border. A large windpipe indicates ability to breathe well. Jawbones placed wide apart indicate capacity in chewing food.

### FOREQUARTERS.

*Shoulders.*—A draft horse should have such a shoulder that the work collar will fit smoothly and with comfort. To accomplish this purpose, the shoulder should not be too steep. Occasionally one meets draft horses with shoulders too sloping. A moderate slope is desirable. The shoulder should be free from all coarseness and roughness and so muscled as to be smooth.

*Arm.*—The part formed by the arm bone, or humerus, extending from the point of the shoulder to the elbow is known as the arm. The arm should be short, heavily muscled, and should slope backward from the point of the shoulder to the point of the elbow so as to bring the leg in such a position as to properly support the weight of the forequarter.

*Forearm.*—The forearm extends from the elbow to the knee. It should be long, heavily muscled, flat, wide, and free from coarseness. The size of the forearm depends upon muscular development, since no fat is placed upon it. The development of the forearm is therefore noted as an indication of muscular development in other parts of the body.

*Knees.*—It is very important that the knees be not only large but also so strongly developed and so perfectly set as to carry well the weight of the body. As much work devolves upon this joint, there are apt to be blemishes which indicate weakness or a tendency to falling. Smoothness, which indicates quality and freedom from any tendency toward blemishes is as important as size.

*Cannons.*—The part of the leg from knee to fetlock is known as the cannon. The cannons should be short and strong. Large sinews set back well from the bone will give them a flat appearance, which is desirable. When long hair or "feather" is present it should be fine and silky as an indication of the quality and strength of bone and sinew.

*Fetlocks.*—The fetlocks, like the knees, are joints which must withstand much strain, and which must be wide, straight, and strong to withstand it. It is very important that they be free from blemishes.

*Pasterns.*—The pasterns, like other parts of the leg, should give evidence of clean, strong bone. The length and slope of the pastern is important. Short, upright pasterns prevent a springy, elastic action in placing the feet, and are apt to send a jar through the body when weight is thrown upon the foot. While long pasterns with too great a slope are less frequently met with in the draft type, they are undesirable, as they tend toward weakness. Moderately long pasterns with a slope of 45° are most desirable.

*Feet.*—Close attention should be given the feet. They should be large, smooth, and symmetrical in shape, giving every evidence of strength and quality. It is more important that the hoof be of good texture and of the proper shape than that it be of a dark color. (Fig. 9.) The sole should be cupped, not flat or bulging. The frog should be large and elastic, the bars prominent. The horn of the hoof should be smooth and waxy, free from cracks, ridges, and scales. The hoof heads (coronets) should be open and wide at the heel.

*Legs.*—After each part of each leg is considered the forelegs may considered in relation to the body. As suggested on the score card they should be straight, so that when viewed from the front a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern, and foot. (Fig. 10.) From the side a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and back of the hoof.

## BODY.

*Chest.*—A roomy chest is an indication of strong constitution. A narrow chest does not give room for the large heart and lungs which the vigorous, powerful horse should possess. The chest should be wide and deep when viewed from the front and from the side. Room for the vital organs should be secured by depth as well as breadth, because a chest too wide may not be consistent with good action.

*Ribs.*—The digestive organs of the animals lie within the so-called barrel. The capacity of the barrel depends upon the ribs. If the digestive organs are to have room the ribs must be long and well sprung. Ribs close together and close up to the hips are associated with strength and good feeding qualities. Ribs with loose coupling not carried close up to the hips indicate weakness and poor digestive powers.

*Back.*—Ribs well sprung will give breadth to the back. The back should not only be broad but also straight, short, and muscular. Its general appearance should be that of great strength and compactness.

*Loin.*—The part of the back not supported by the ribs is known as the loin. If the ribs are carried close up to the hips the loin will be short. With the back is should be straight and wide and give evidence of strength.

*Underline.*—The underline should run back well, full and low. If it is cut up at the flank it will denote the lack of capacity associated with a horse hard to keep fat.

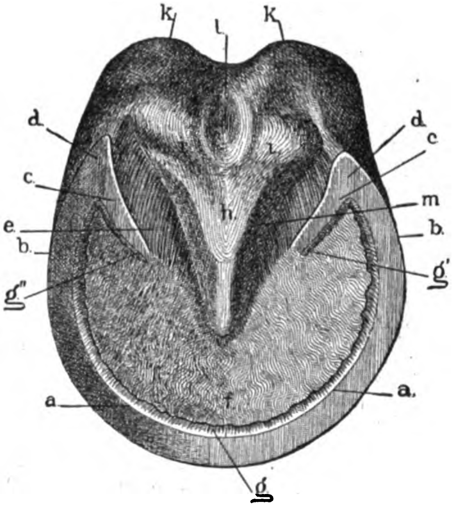

FIG. 9.—Ground surface of a right fore hoof of the regular form: *a, a,* wall; *a–a,* the toe; *a–b,* the side walls; *b–d,* the quarters; *c, c,* the bars; *d, d,* the buttresses; *e,* lateral cleft of the frog; *f,* body of the sole; *g, g', g'',* leafy layer (white line) of the toe and bars; *h,* body of the frog; *i, i,* branches of the frog; *k, k,* horny bulbs of the heels; *l,* middle cleft of the frog.

### HINDQUARTERS.

*Hips.*—The hips should be wide and smooth and free from angularity and coarseness. As the muscles of the upper region of the hindquarters are important in the movement of heavy loads, there should be plenty of room about the hips and croup for thick muscle.

*Croup.*—While draft horses are not carried out so well in the croup as horses of lighter type, there should be no excessive drooping. A steep, short croup does not give room for the necessary muscle, hence is an indication of weakness.

*Tail.*—The tail itself is not important except as a factor in the appearance of the horse and its comfort during fly time. While it can not be expected that the tail of a draft horse will be carried with the style of a lighter harness horse, it should be attached fairly high and carried well.

*Thighs and quarters.*—The thighs extend from the hips to the stifles. The plump muscles of the thigh seen from the rear are known as the quarters. Thighs and quarters should have strong muscles extended down well to the stifles and gaskins.

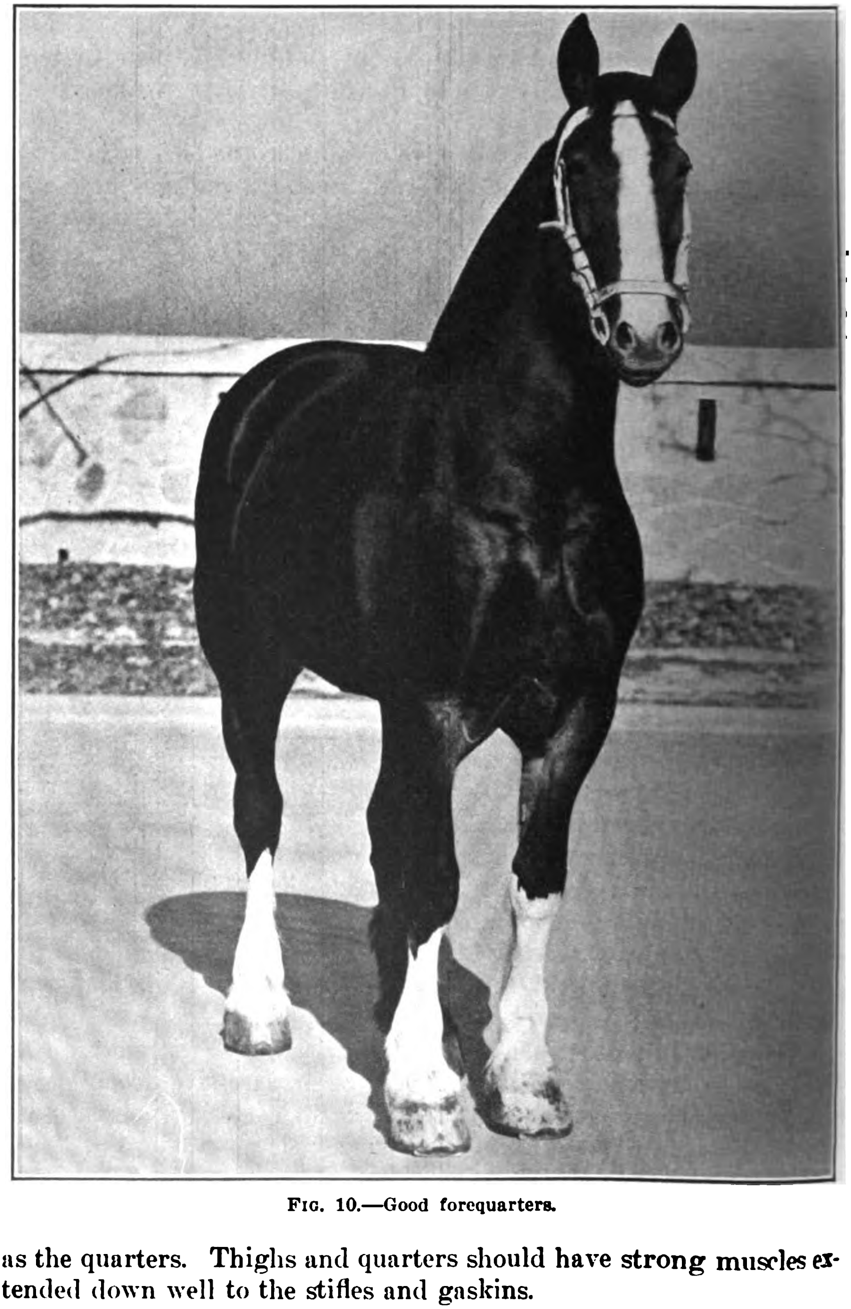

FIG. 10.—Good forequarters.

*Stifles.*—These joints correspond to the knee of a man. Th should be strong, clean, and muscular, and so set as to allow freedo in action. It is better to have them turn outward slightly than have them turn inward.

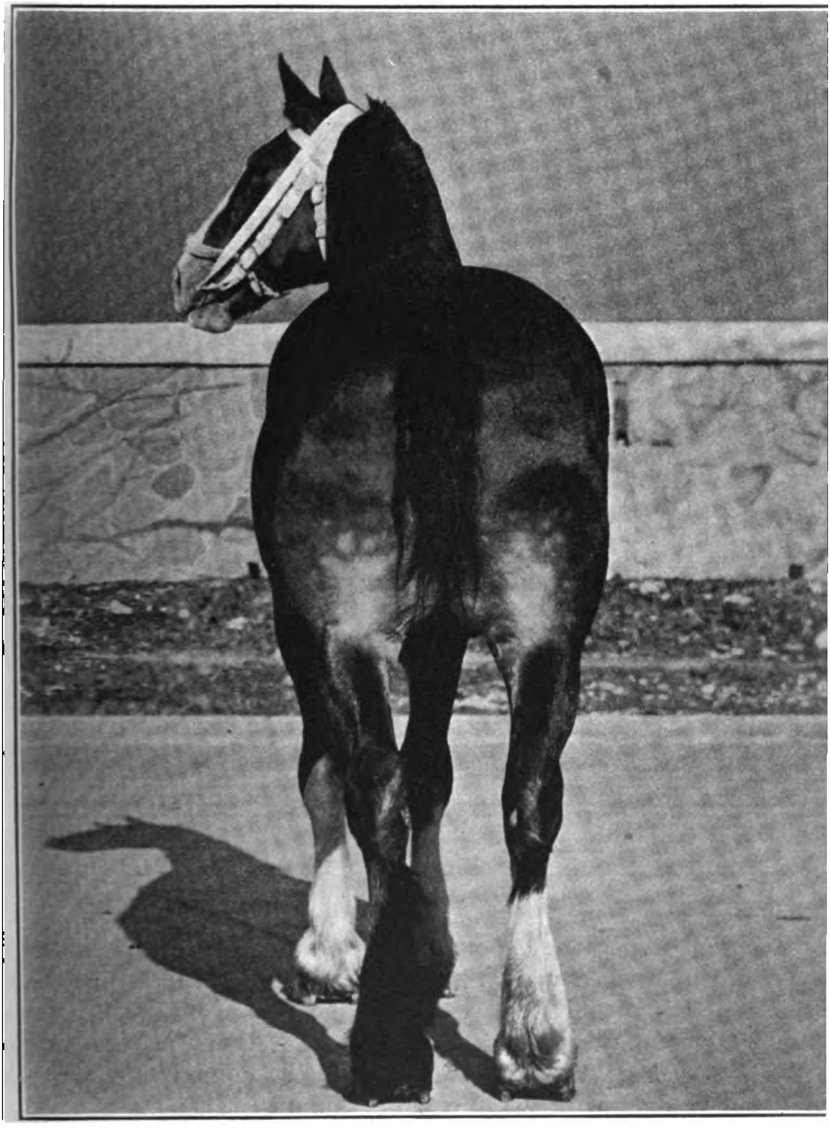

Fig. 11.—Good hind quarters.

*Gaskins.*—The gaskins, or lower thighs, like the forearms, shou be long, heavily muscled, flat, wide, and free from coarseness. T muscles should be prominent in front of the bone and carried w downward.

*Hocks.*—The hocks are even more important than the knees, as the strain of starting a load and heavy hauling devolves upon these joints. They should be perfectly sound and show great strength. To show strength they should be large, well defined, clean, and straight.

*Cannons, fetlocks, pasterns, feet.*—Statements regarding the lower part of the front leg will apply equally well to the corresponding parts of the hind leg.

*Legs.*—As the hind legs are more important in pulling a load, it is even more important that they are straight than it is that the front legs are not crooked. As suggested in the score card when viewed from behind, a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern, and foot. (Fig. 11.) From the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle, and a perpendicular line from the point of the buttock should run parallel with the line of the cannon.

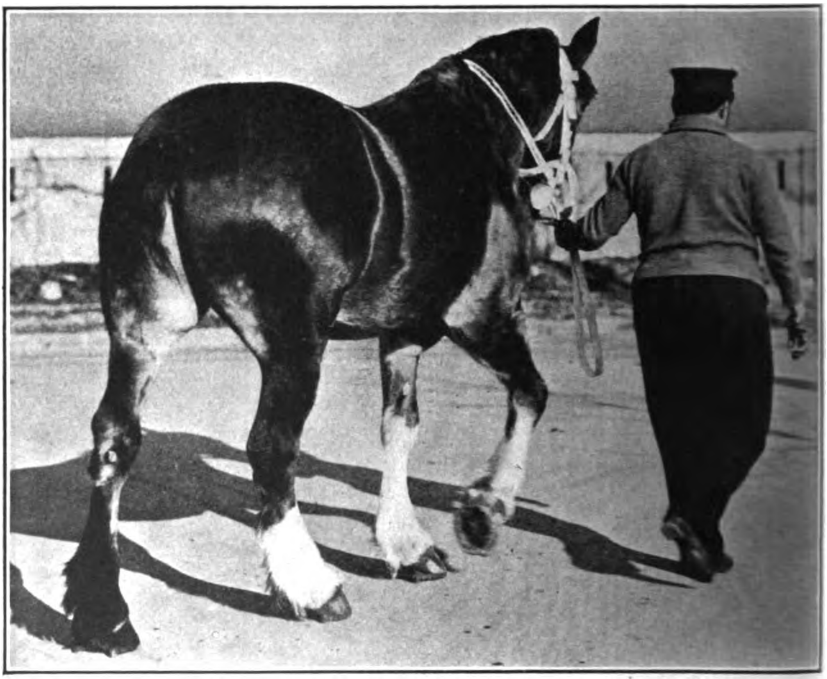

FIG. 12.—Judging action. Horse moving away from student at a walk.

### ACTION.

*Walk.*—Inasmuch as most of the work of a draft horse is done at a walk (figs. 12, 13, and 14) in the score this gait is given more weight than the trot. It is important that a working horse maintain a fast walk throughout the day. The student should note the horse as he moves away at a walk. The walk should be straight, rapid, and well controlled. The joints should be fully flexed, and the hoofs turned up so that the shoe shows plainly. The hocks should be carried neither too wide nor too close together. The student should also note the horse carefully as he comes back at a walk. The feet should be lifted with a snap and move straight ahead. The flexing of the knee should not result in any outward spreading. The horse should also be taken past the students at a walk, when the length of the stride and the flexing of the joints may be noted to better advantage.

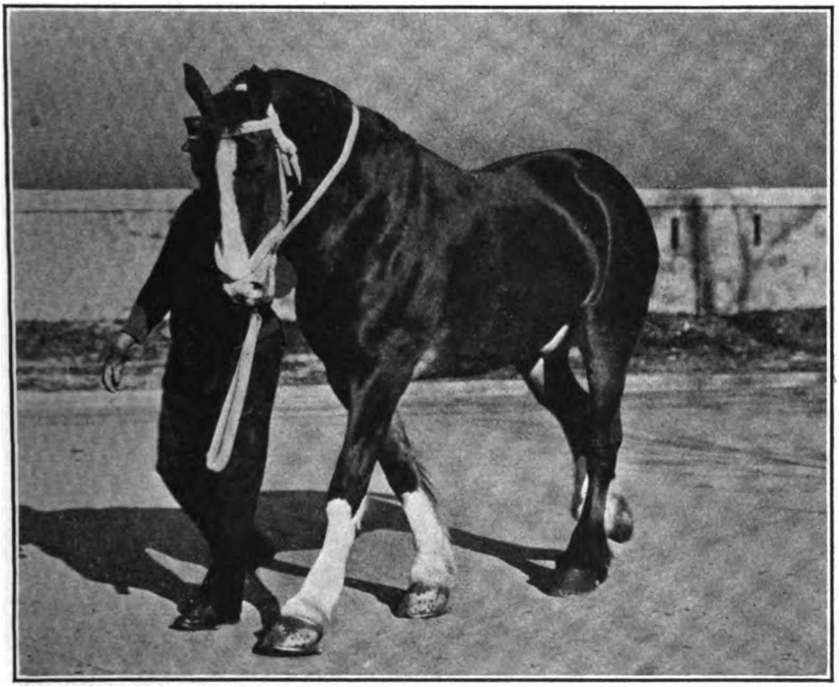

FIG. 13.—Judging action. Horse moving toward student at a walk.

*Trot.*—The trotting of the horse should be noted likewise as the horse is moving away, as he is coming toward the student, and as he is passing by. The action should be even and well balanced and should show spirit. If the feet are brought down too close together there may be interfering; if they are spread too wide there will be a spraddling gait. When the legs are placed too wide on the body there will be an undesirable rolling gait. The joints should be flexed well, that there may be no danger from stumbling. The stride should be long and even, and the feet brought down so that the heel meets the ground first. This latter action is associated with pasterns of good slope and gives a spring not associated with short, upright pasterns.

### LIGHT HORSES.

*Relation of form to function.*—The demand made upon the draft horse is to pull a heavy load; this function is associated with weight and great strength. The demand made upon the light-harness horse is to move a relatively light vehicle at a rapid rate; this function is associated with a lighter, more angular form and great endurance.

### GENERAL APPEARANCE.

*Height and weight.*—The most desirable height for a light-harness horse, or roadster, is from 15 to 15½ hands. They may range in weight from 900 to 1,150 pounds, the weight most desired being 1,000 to 1,100 pounds.

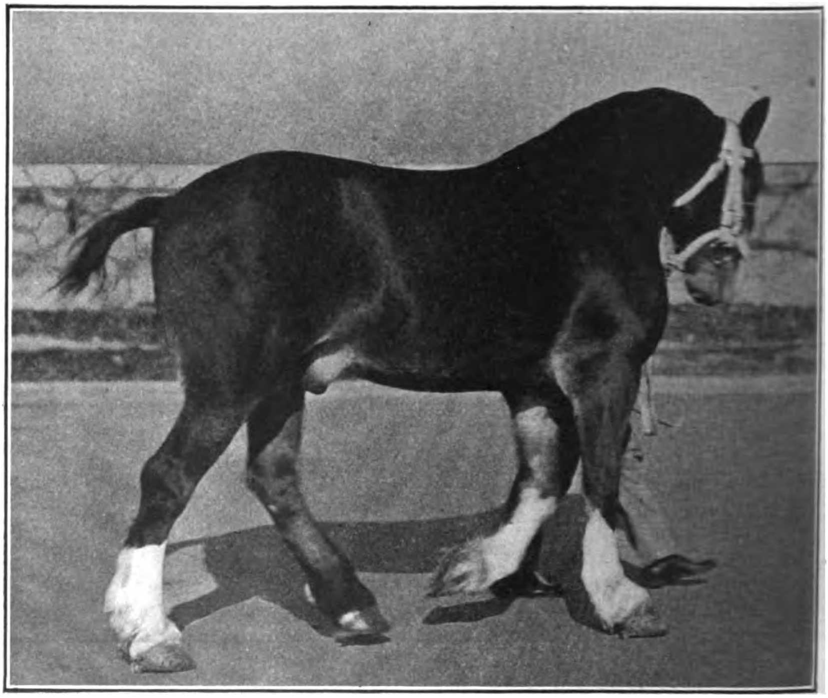

FIG. 14.—Judging action. Horse moving past student at a walk.

*Form.*—Angularity with length of body and limbs is an indication of speed. There should also be sufficient depth of chest to indicate capacity of vital organs so closely correlated with stamina.

*Quality.*—In the light-harness horse there should be a complete absence of coarseness. There is a very close correlation between quality and endurance, as well as with style, spirit, and speed. It is especially important that the legs and feet show every indication of quality.

*Temperament.*—The temperament as reflected in action and general behavior should be very energetic, yet manageable. Horses true to this type are not often sluggish, although there may be a tendency toward excessive nervousness and even viciousness.

### HEAD AND NECK.

That which is stated in regard to the head of the draft horse applies also to horses of this type, except that we may expect the head of the light horse to be somewhat more lean and angular.

While style and grace are desired in the neck of the light-harness horse, it will be long when compared with that of the draft horse, and may in some horses lack the pronounced style and symmetry of the coach horse.

### FOREQUARTERS.

Clean and quick action will depend much upon the conformation of the shoulder. A long-reaching, clean action demands a shoulder long and oblique, extending well into the back. It is important that the covering of muscle should be smooth.

The statements made concerning the forelegs of the draft horse will apply for the most part to the light-harness horse. The length of muscle and bone will be proportionally greater in the light horse. There should be an absence of all coarseness, and every indication of quality.

### BODY.

A strong constitution is indicated by the light horse more by depth of chest than by breadth. The ribs should be well sprung, deep, and close. The back should be short and well muscled as an indication of strength. The loin should be short and broad and the croup long and level. Both loin and croup should be well rounded out with strong muscles.

### HINDQUARTERS.

As with the forequarters, so with the hindquarters, the limbs with their body connections should be constructed for speed. The muscles of the thighs, quarters, and gaskins should be long and heavy. The hocks should be wide, straight, and clean. The cannons should be comparatively short and give evidence of clean bone. The pasterns should have a good slope. The feet and legs should be given special attention.

### ACTION.

It will be noted that the score cards give relatively more value to action with light horses than with the draft horses. The greater amount of value is given entirely to the trot. When we consider the functions of these classes of horses we see good reason for this. Special attention should be given the trot or pace according to the directions given under the description of the draft horse. The light horse should not come down on his heels in a pronounced manner.

## ESTIMATING THE AGE OF A HORSE.

Every student should learn to estimate the age of a horse. When a horse is scored each student should put his estimate of the horse's age upon the card. Horses of different ages should be selected in order that the student may note their development and have practice in estimating ages. (Fig. 15.)

Until a horse is over 10 years old the teeth furnish an indication of age which is fairly accurate. In estimating the age of a horse we consider only the three pairs of front teeth or nippers on each jaw. Horses, like human beings, have two sets of teeth; the first set, known as milk teeth, being replaced by permanent teeth. New teeth have deep cups, or indentations, at their centers. As the teeth wear down these cups disappear.

A colt does not usually get its first pair of nippers until it is a few days old, and has all three pairs by the time it is 6 to 10 months old. Until a colt is 3 years old, its general appearance is relied upon largely as an indication of its age. The following descriptions, with the accompanying illustrations, are intended to aid the student in getting an idea of the condition of a horse's mouth by years:

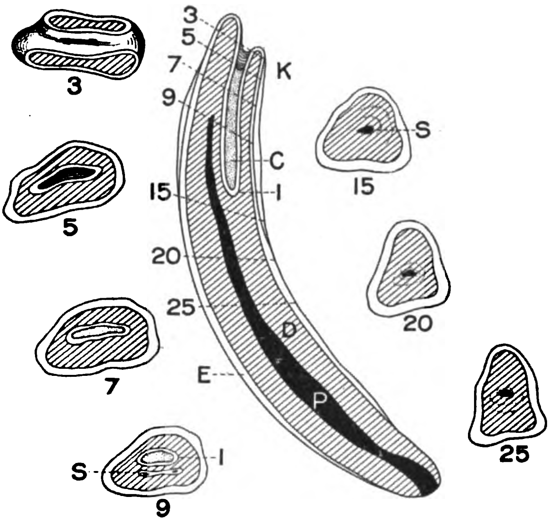

FIG. 15.—Age of horses as indicated by teeth.

Longitudinal section of left central lower incisor and cross sections of same tooth, showing table surfaces as they appear at the ages of 3, 5, 7, 9, 15, 20, and 25 years. C, Cement; I, infundibulum; D, dentine; K, cup; S, star; E, enamel; P, pulp cavity.

*One year.*—The center pair of milk incisors, known as the pinchers, and the pair next to them, known as the intermediates, are well through the gums and in contact, but the corner pairs do not yet meet on a level.

*Two years.*—The pinchers and the intermediates indicate that they are being crowded by the permanent teeth, as they are pushed free from their gums at the base. By the time the colt is two and a half years old the middle pinchers should be through. The permanent teeth are much larger than the temporary ones.

*Three years.*—The middle pinchers are large enough for use. Their deep cups show plainly. The milk intermediates are about to be shed.

*Four years.*—The permanent intermediates appear at three and a half years and are ready for use at four. The corner teeth give evidence that the permanent corners are coming. The cups in the pinchers are about one-third gone. (The tusks, or canine teeth, of male colts may appear about this time.)

*Five years.*—The temporary corner teeth are shed at four and a half and the permanent ones are ready to use. The horse has now what is known as a full mouth, all permanent incisors being ready to use. The cups of the first pair are about two-thirds gone.

*Six years.*—The cups in the center pair have nearly disappeared. In the second pair they are about two-thirds gone.

*Seven years.*—The cups from the second pair are now gone. There is a notch in the upper corner tooth where it overlaps the lower one.

*Eight years.*—The cups having all worn out of the lower nippers, we now look at the upper jaw. Although cups remain in the center pair, they are not deep.

*Nine years.*—The cups in the center pair of nippers on the upper jaw have disappeared. They are still present in the other two pairs, being fairly deep in the corner ones.

*Ten years.*—The cups are worn out of the second pair on the upper jaw, although they are still present in the corner pair.

*Older horses.*—At 11 years all of the cups are usually worn out of the incisors. It becomes necessary now to use some other indication of age. Estimation of age is now based upon the angle at which the teeth meet, their change in size and shape. As the horse gets older, the teeth meet more and more at an acute angle; that is, the jaws become more oblique. As the teeth wear down, the shape of the worn ends changes from oval to more nearly round and finally, in an aged horse, to a nearly triangular form. Students should note the difference in the shape of the teeth in younger horses. Sometimes cups are cut or burned in the teeth of old horses to make their mouths resemble those of younger animals. This practice, known as "Bishoping," may be detected if the shape of the tooth and the absence of the ring of enamel which surrounds the natural cup are noted. After a horse is 12 years old its condition is more important than its age in determining values.

## ESTIMATING MATTERS OF UNSOUNDNESS.

Sound horses should be selected for practice judging until the students have become well acquainted with the score card and have developed fairly good ideals. A sound horse is one which has no imperfection of so serious a nature as to interfere with its usefulness. Anything, such as a wire cut, which mars the appearance of a horse without detracting from its usefulness is known as a blemish. .

The matter of detecting unsoundness is very important in judging horses, as many forms of unsoundness not only unfit a horse for hard work but also unfit it for breeding purposes, as the unsoundness may be transmitted to the offspring. It is a question, however, as to just how far the high-school student may enter into this study. A knowledge of many of the troubles which detract from the value of horses is based upon principles of veterinary science not commonly taught in the high school. Only the more common and important defects and diseases are listed below under the part affected. (Fig. 16.) The extent to which the class will consider matters of unsoundness and disease should depend upon the training of the teacher and the preparation of the students. An effort should also be made to meet local conditions and needs.

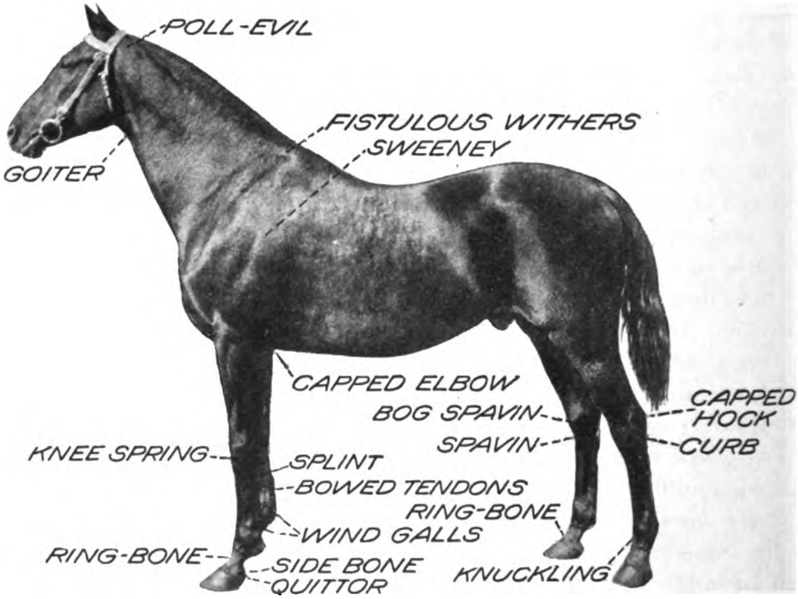

FIG. 16.—Location of common unsoundness.

*Eyes.*—The student should gain assurance that the horse is not blind. Blindness may frequently be discovered by placing the hand gently in front of the eye, and moving it gently directly away from the eye so as not to create air waves which might cause a blind horse to close the eyelids. An inclination to shy readily may indicate defective vision.

*Ears.*—If the ears are kept rigid it may indicate deafness. If the ears are used excessively it may indicate defective sight, as a horse which does not see well will use his ears to the fullest extent to assist his eyes.

*Nostrils.*—The nostrils should show a healthy pink color and be free from discharges which might indicate some disease.

*Mouth.*—The lips should not be torn and should be free from any sores caused by the bit. See that the tongue shows no evidence of mutilation. Good teeth will meet well all around. A strong odor from the mouth may indicate decayed teeth. Look at the under jaw for abcesses and tumors.

*Neck.*—The neck may be left stiffened by a case of poll evil, which is a fistula or enlargement of the poll containing pus. This trouble may reappear.

*Withers.*—A similar fistula may occur upon the withers. These fistulas may be chronic and difficult to heal, or when healed leave bad scars and stiffness, which would constitute unsoundness if the serviceableness of the horse is interfered with.

*Shoulders.*—There may be a wasting away of the muscles, causing what is known as sweeney.

*Knees.*—The knee may be bent forward, causing what is known as "sprung knee," or it may be bent backward indicating "calf knee," which is caused by an inherited defect of conformation. Look also for puffs or swellings.

*Cannons.*—Associated with the cannons are two small splint bones. There may be abnormal bony growths about these bones which are known as splints. Small splints may not cause lameness, and if found on young horses may be classed as blemishes, since they may disappear as the horse grows older. A splint is considered serious if located so as to interfere with the action of the tendon or so close to the knee joint as to interfere with action.

*Fetlocks.*—Wind galls and sores due to interfering may be present and are classed as blemishes unless they produce lameness.

*Pasterns.*—Ringbones may be found upon the pasterns. These are bony growths which may encircle the bone partially or entirely. They may be up near the fetlock, but are more commonly down lower where the hoof joins the pastern. A well-developed ringbone has a bulging appearance and is readily seen. A small form may need the hand for detection.

*Hoof heads or coronets.*—Side bones are abnormal bony growths appearing as a swelling under the skin in the region of the coronet. They are common only upon the front feet. They have been developed by the cartilage changing to solid bone. They may cause lameness and pain, especially when the horse is driven on hard pavement. A fistulous abscess, known as quittor, may also occur upon the coronet.

*Feet.*—Founder is indicated by rings and ridges around the hoof wall, an abnormal projection of the toe, and a convex sole. (The rings and ridges are close together at the toe and diverge toward the heel.) Founder also causes lameness. Weak feet are subject to cracking. A crack in front of the foot is known as a sand crack, and those on the quarters are known as quarter cracks. Upon the soles of the feet there may be corns, or a diseased condition of the frog known as thrush.

*Hocks.*—It is very essential that the student knows the structural outline of a perfect hock, otherwise it will be difficult to detect certain unsoundness common to this region. Thoroughpin is one of the troubles often difficult to detect. It consists of a soft swelling having its origin between the tendon and the bone, appearing just above the hock.

There may be associated with thoroughpin a trouble known as bog spavin. This trouble is found in the depression that occurs on the inner forward part of the hock. It is caused by the oil from the joint accumulating and forming a soft swelling. Sometimes the term blood spavin is applied to these swellings and to an enlargement of the vein that passes the hock from the front. None of these troubles are considered unsoundness in a technical sense unless they are productive of lameness. Just under the hock at the rear the ligaments may thicken, forming a bulging calloused enlargement known as a curb.

The worst trouble of the hocks and the most common is bone spavin. Nature in her attempt to strengthen a weak hock often causes a deposit of bone about the joint. Needless to state that this interferes with action, causing lameness. The lameness usually lessens with exercise.

*Stifle.*—Be sure there are no swellings about the stifle.

*General unsoundness.*—It is necessary to drive a horse hard for some distance to determine if his wind is sound. By stopping him quickly and listening in a position close to the neck it may be determined whether the breathing is natural. There may be a roaring or whistling sound indicating disorders of the air passages. Irregular, spasmodic breathing indicates heaves, another unsoundness of the horse.

*Vices.*—Such vices as kicking, balking, shying, and a tendency to run away are not met with in draft horses to the extent that they occur in lighter horses. Stable vices such as cribbing, weaving, tail rubbing, and halter pulling, as well as the vices mentioned above, detract from the value of the horse, although they are not considered unsoundness.

## COMPARATIVE JUDGING.

The score card has been used in order that the student might establish in his mind an ideal of a draft horse. The judging so far has been a comparison of the horse judged with the ideal. The use of the card should have trained the student to examine the horse in a systematic manner, taking in all details. After these aims have been attained the student is ready for work in comparative judging; that is, in comparing a horse with other horses in place of comparison with the score-card ideal.

In considering the superiority of one horse over another, it is necessary to merge details into more inclusive qualities or characters which affect values directly, such as size, conformation, quality, temperament, action, and soundness. It is well to have students begin by making comparisons in simple features, placing the horses as to weight, quality, or general conformation. As they become proficient in making comparisons, a number of horses may be placed according to their market or breeding values. Horses of marked differences may be chosen at first, and later horses more nearly equal may be used. Each student should write a report covering his reasons for placing the horses. These reasons may be graded by the teacher and discussed later in the class.

## DEMONSTRATIONS.

Demonstrations are usually conducted by the teacher or some expert induced to point out the good and bad points for the benefit of the class. After the students have developed proficiency in judging, a member of the class should be called upon to discuss the merits and defects of an individual or to give his reasons for placing in comparative judging in the presence of the animals.

*Judging at fairs.*—Competitive stock judging at fairs and stock shows has become very popular in some sections. If these competitions are conducted honorably and with the students' development paramount, they have high educational value. Whether students enter a judging competition or not, much may be learned by the student at these shows. A progressive teacher will take advantage of live-stock exhibitions and will aim to organize the students and supervise their visit so that maximum results may be obtained. The better fairs not only give the students an opportunity to see the best horses of the section represented, but they also give them an opportunity to observe the methods of judges of experience. The work of the judges should be observed closely by the visiting class, and explanations of reasons for their placing noted carefully. The fairs give an opportunity for comparison of types and breeds which is seldom found in the school district.

At some of the schools local fairs are held in connection with the work in stock judging. Such exhibitions aid in arousing interest in better animals as well as give students practice in judging. A program may be given in connection with the show. While men well qualified should give the main addresses concerning horses, a place should be reserved for the members of the class. A debate on some question pertaining to types and breeds of horses should be interesting as well as instructive.

## REFERENCES ON HORSE JUDGING.

Score Card in Stock Breeding. U. S. Dept. Agr., Bur. Anim. Indus. Bul. 76 (1905).

Score Card in Stock Judging at Agricultural Colleges. U. S. Dept. Agr., Bur. Anim. Indus. Bul. 61 (1904).

Breeds of Draft Horses. U. S. Dept. Agr., Farmers' Bul. 619 (1914).

Breaking and Training Colts. U. S. Dept. Agr., Farmers' Bul. 667.

Examination of Horses for Serviceableness. U. S. Dept. Agr., Farmers' Bul. 779.

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UNITED STATES DEPARTMENT OF AGRICULTURE

**BULLETIN No. 488**

Joint Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief, and the Bureau of
Animal Industry, A. D. MELVIN, Chief

Washington, D. C. ▲ February 26, 1917

# EXPERIMENTS IN THE DISPOSAL OF IRRIGATED CROPS THROUGH THE USE OF HOGS.[1]

By James A. Holden, *Assistant, Office of Western Irrigation Agriculture.*
In cooperation with the Bureau of Animal Industry.

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## INTRODUCTION.

The farmer who makes a success on high-priced irrigated land must not only grow large crops, but he must market these crops in the most advantageous way. Most crops grown in localities far removed from the large consuming centers should be marketed in condensed form, so as to reduce the cost of transportation. For example, a hundred pounds of butter can be shipped to market much more cheaply than the hay and grain required to produce this butter. The farmer should take advantage of this fact in organizing his operations. In addition to this saving, the manure resulting from the feeding of the crops makes it possible to produce larger crops in subsequent years.

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[1] The experiments reported in this bulletin have been conducted on the Scottsbluff Experiment Farm on the North Platte Irrigation Project in Nebraska. This experiment farm is conducted by the United States Department of Agriculture in cooperation with the State Experiment Station of Nebraska. The primary object of these experiments has been to determine the most efficient method of utilizing alfalfa, which is the most important crop on this project, as it is on nearly all of the irrigated projects of the West. The author desires to acknowledge the assistance given him by Mr. Henry Sullivan in carrying out the details of the experiments.—*C. S. Scofield, Agriculturist in Charge, Office of Western Irrigation Agriculture.*

Many of the farmers on irrigated projects are financially unable at present to secure dairy cows or to get cattle or sheep to feed. There are very few, however, who can not get into the hog business in a very short time. Less capital and time are required in getting into the hog business than in any other live-stock industry. With $25 with which to buy small pigs and with very little grain and good alfalfa pasture, the farmer can get well started in the hog business in two years. Horses and cattle increase annually 60 to 80 per cent, sheep a little more than 100 per cent, while hogs should increase 600 per cent or better. The buildings necessary for the housing of hogs are also relatively inexpensive. The hog is a very economical feeder. It takes less feed to produce a pound of pork than any other kind of meat produced on the farm. The hog has the ability quickly to transform the products of the farm into a readily marketable commodity.

In the irrigated sections of the West, where alfalfa is the principal crop and where grain crops occupy a secondary position, the farmer needs information on the following points: (1) The practicability of using alfalfa as hog pasture; (2) the value of different quantities of grain when fed to hogs on alfalfa pasture; (3) the comparative values of corn and ground barley when fed to hogs on alfalfa pasture; and (4) the practicability of hogging down corn.

In order to secure information on these points, experiments were inaugurated at the Scottsbluff Experiment Farm on the North Platte Reclamation Project in 1912 and continued with some modifications in 1913, 1914, and 1915. The results of these experiments are reported in this bulletin.

## GENERAL DESCRIPTION OF THE METHODS FOLLOWED.

It has been the aim in this bulletin to use average prices and to report sufficient fundamental data to enable anyone to apply different prices to the results. The prices used, except where otherwise stated, are as follows: Gains made by hogs, $7 per hundredweight; corn, $1.07 per hundredweight (or 60 cents a bushel); ground barley, $1 per hundredweight; alfalfa hay, $8 a ton; tankage, $64 a ton. The data, which usually have been calculated to an acre basis, show the results that were obtained from quarter-acre plats of alfalfa pasture, which, if cut for hay, would have yielded from 4 to 6 tons per acre; and in the case of corn hogged, from one-third or one-quarter acre plats that yield as high as 80 bushels of corn per acre. It must be remembered by farmers who attempt to follow these methods of crop utilization that the higher the yield of the crop the larger will be the returns.

The term "per cent," when referring to rations, indicates the number of pounds fed daily per 100 pounds of live weight. The cost of the condiments fed, sprays used, interest on investment, risk, and labor are not considered in this report. The term "net return," as used in the following text and tables, refers to the difference between the total return and the estimated value of grain fed and is not to be taken as the net return of the land after production costs and interest charges have been deducted.

The hogs in these experiments had access to salt, slacked coal, and rock phosphate most of the time. They were also sprayed with coal-tar creosote every two or three weeks to keep them free from lice. In fact, they received the treatment that every farmer should give his hogs. The hog usually receives the least care and consideration of any farm animal. It is commonly believed that anything is good enough for hogs, but, on the contrary, the hog will respond as much to good care and treatment as any kind of live stock. Regularity in feeding, both in time and quantity of feed, clean quarters, and freedom from lice are three very important factors that are essential to successful hog raising; and these were provided in the experiments under consideration. The data here reported are the results of tests covering one to four years. In the alfalfa pasturing experiment, two lots of hogs were used each season, and in the corn hogging experiment, with supplemental feeds, duplicate lots were used.

## ALFALFA PASTURING EXPERIMENTS.

### ALFALFA PASTURE SUPPLEMENTED WITH A 2 PER CENT RATION OF CORN.

The alfalfa pasturing experiments were begun in 1913 and continued in 1914 and 1915. Each year a quarter-acre plat was used. The plat was divided into two equal parts and the hogs were changed from one to the other as the pasture became short. This allowed the alfalfa to recuperate and at the same time provided fresh, palatable feed. It was the plan to pasture the alfalfa to its full carrying capacity but not to overgraze. This made it necessary to remove some of the hogs during the latter part of the experiment, for as the season advanced and the nights became cool the alfalfa made slower growth and at the same time the hogs were increasing in size, thus requiring more feed. A few times during periods of three or four days of cloudy weather and also during the last month, when alfalfa was making little growth, the plats were perhaps slightly overpastured. As far as could be determined, however, no plat was pastured more heavily than another.

The corn was fed on the ear during the first period, and shelled corn was fed during the second period. Ear corn was fed on the ground and the shelled corn in a trough. The barley was ground and fed as a thick slop. Grain was fed once a day, in the evening. It is believed that when fed grain but once a day the hogs will make more use of the pasture than when grain is fed both morning and evening, as is usually the case. When not fed until evening, the hogs become hungry and will graze during the cool hours of the evening, even after the grain is eaten. Again, if the hogs are not fed grain in the morning they will stay out on pasture until the heat of the sun drives them to shade. The method of feeding grain once a day also saves labor.

During the pasturing season two sets of hogs were used. Fall-farrowed shotes were used during the first period and spring-farrowed pigs during the second period. In 1914 this plan was not followed strictly, as it was necessary to use a few fall-farrowed pigs throughout the season, owing to the loss of spring pigs from cholera. The reason for using two sets of hogs is that fall-farrowed pigs when fed a liberal grain ration are ready for market about July 15, and April-farrowed pigs are not large enough to utilize the pasture much before that date.

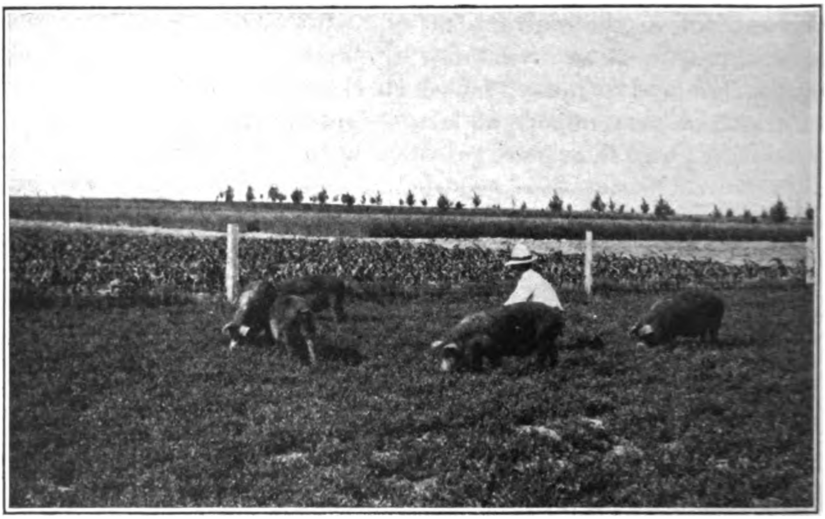

FIG. 1.—Five fall-farrowed shotes on alfalfa pasture supplemented with a 2.3 per cent ration of corn during the first period in 1913. These shotes in 61 days gained 381 pounds from one-fourth of an acre of alfalfa pasture and 1,047 pounds of corn.

### EXPERIMENTS IN 1913.

Five thrifty fall-farrowed shotes, weighing a total of 544 pounds, were turned on a quarter-acre plat of second-year alfalfa on May 2. The five shotes were all the plat would carry. They were removed from the plat on July 2, when they weighed a total of 925 pounds, having gained 381 pounds during the 61 days they were on the plat. While on pasture these hogs were fed 1,047 pounds of corn, at the rate of approximately 2.3 pounds daily for each 100 pounds of live weight. Figure 1 shows the five shotes on alfalfa pasture.

On July 6, eight spring pigs, weighing a total of 273 pounds, were put on the alfalfa plat from which the previous lot had been removed. It was soon apparent that these eight pigs would not keep the pasture fed down, and on July 20 four more, weighing a total of 139 pounds, were added. All 12 pigs were unable to keep the pasture fed down during the early part of the period, so that it was necessary to clip the alfalfa once on each half of the plat. The 12 pigs were kept on this plat until September 10, when 6 were removed, the other 6 remaining until September 30. During September, however, the pasture made but little growth and the 6 pigs gained only 59 pounds during the 20-day period. While on the alfalfa pasture, the hogs gained a total of 697 pounds from the quarter-acre plat of alfalfa and 1,267 pounds of corn, the latter being fed at the rate of approximately 2.3 pounds daily for each 100 pounds of live weight.

The results secured in 1913 with these two lots of hogs on alfalfa pasture are summarized in Table I, in which the data have been calculated to an acre basis.

TABLE I.—*Results obtained by feeding two lots of hogs on alfalfa pasture, supplemented with approximately a 2 per cent corn ration, at the Scottsbluff Experiment Farm in 1913.*

| Items of comparison. | First period. | Second period. | Entire season. |
|---|---|---|---|
| Number of hogs | 20 | 48 | .......... |
| Total gain per acre ........ pounds.. | 1,524 | 2,428 | 3,952 |
| Average daily gain per acre ........ do.... | 24.8 | 28.2 | 26.1 |
| Corn fed ........ do.... | 4,188 | 5,068 | 9,256 |
| Grain per pound of gain ........ do.... | 2.75 | 2.09 | 2.34 |
| Gain per 100 pounds of grain ........ do.... | 36.4 | 49.8 | 42.7 |
| Financial statement: | | | |
| Net returns per acre of pasture | $61.88 | $115.72 | $177.60 |
| Daily net returns per acre of pasture | 1.01 | 1.35 | 1.17 |
| Cost per 100 pounds of gain (pasture at $15 per acre) | 3.25 | 2.64 | 2.88 |
| Equivalent paid for hay, per ton | 33.63 | 32.07 | 32.85 |

A very important fact shown in Table I is the large number of hogs carried per acre of alfalfa pasture. From May 1 to July 2 the carrying capacity of an acre was at the rate of 20 hogs with an average initial weight of 108.9 pounds, and from July 20 to September 10 the carrying capacity was at the rate of 48 hogs with an average initial weight of 39.8 pounds. The total final weight of the first lot was 3,700 pounds, whereas the total initial weight of the second lot was only 1,900 pounds. This shows that the smaller the hogs the less total live weight the pasture will carry; that is to say, twenty 25-pound pigs will require more pasture than an equal weight of 100-pound shotes.

From a farmer's standpoint a very significant fact shown in Table I is the high return per acre of alfalfa pasture after the value of the corn fed is deducted from the value of the gains. With the first lot this was $61.88 and with the second lot $115.72, or a total of $177.60 per acre for the season. If it is assumed that the value of the labor necessary to care for the pigs is equal to the cost of harvesting the hay crop, the hogs paid an equivalent of $33.63 a ton for the first cutting and $32.07 a ton for the second and third cuttings. This estimate is based on the assumption that the pastured plat would have produced hay at the same rate as the average of 11 similar plats in the same field. On the North Platte project $6 a ton in the stack is considered a good price for alfalfa hay. Considering these facts, the high value of hogs as a means of marketing alfalfa is clearly apparent. It required 2.75 pounds of corn for the first lot and 2.09 pounds for the second lot for each pound of gain made. With alfalfa pasture valued at $15 per acre for the season ($5 for the first period and $10 for the second) and corn at $1.07 per hundredweight, each 100 pounds of gain in the first lot cost $3.25 and in the second lot $2.64, or an average of $2.88 for the two lots. This emphasizes the value of alfalfa pasture as a hog feed.

### AVERAGE OF THREE YEARS' RESULTS.

Substantially the same methods were followed in 1914 and 1915 as in 1913, as outlined above. Each year, fall-farrowed pigs were used in the first period and spring-farrowed pigs in the second period, except in 1914, when, because of losses from cholera, it was necessary to use fall pigs during the entire season. In 1915 there were two lots receiving the 2 per cent corn ration, so that during the three years there have been eight lots in all, four in each pasturing period. The results of the three years' tests with these eight lots are summarized in Table II, in which the data have been calculated to an acre basis.

TABLE II.—*Results obtained by feeding eight lots of pigs on alfalfa pasture, supplemented with approximately a 2 per cent corn ration, at the Scottsbluff Experiment Farm in 1913, 1914, and 1915.*

| Items of comparison. | First period. | Second period. | Entire season. |
|---|---|---|---|
| Number of lots averaged | 4 | 4 | 8 |
| Total gain per acre ... pounds | 1,271 | 1,910 | 3,181 |
| Corn fed ... do | 3,671 | 4,173 | 7,844 |
| Grain per pound of gain ... do | 2.88 | 2.18 | 2.47 |
| Gain per 100 pounds of grain ... do | 34.7 | 45.9 | 40.5 |
| Financial statement: | | | |
| Net returns per acre of pasture | $49.70 | $89.05 | $138.75 |
| Cost per 100 pounds of gain (pasture at $15 per acre) | 3.36 | 2.86 | 3.11 |
| Equivalent paid for hay, per ton | 22.19 | 27.13 | 25.13 |

On an acre basis, the four lots made an average total gain of 1,271 pounds during the first period and 1,910 pounds during the second period, or a total of 3,181 pounds for the season. During the first period the hogs were fed 3,671 pounds of corn and during the second period 4,173 pounds, or a total of 7,844 pounds during the season. It required 2.88 pounds of corn in the first period and 2.18 pounds in the second period, in addition to the alfalfa pasture, to produce 1 pound of gain. For every 100 pounds of corn fed the hogs made a gain of 34.7 pounds during the first period and 45.9 pounds in the second period, or an average of 40.5 pounds during the season.

With hogs at $7 per hundredweight and corn at $1.07 per hundredweight the net return per acre of alfalfa pasture was $49.70 for the first period and $89.05 for the second period, or a total of $138.75 for the season. This is equal to a daily net return of 90 cents an acre for the entire period of 154 days. If a charge of $5 for the first period and $10 for the second period is made for an acre of alfalfa pasture, the feed required to produce 100 pounds of gain cost $3.36 during the first period, $2.86 during the second period, and $3.11 for the season.

Alfalfa plats similar to those pastured and in the same field have each year been harvested for hay. The three-year average yield of these plats was 5.52 tons per acre, or 2.24 tons for the first period and 3.28 tons for the second period of pasturing. On the basis of this yield, if it is assumed that the cost of caring for the hogs is equal to the cost of harvesting the hay, the hogs in the first period paid $22.19 and in the second period $27.13, or an average for the season of $25.13 a ton for alfalfa hay.

## ALFALFA PASTURE WITH VARIOUS GRAIN SUPPLEMENTS.

### EXPERIMENTS IN 1914.

In 1914 experiments were inaugurated to secure information regarding (1) the most economical quantity of corn to feed to hogs on alfalfa pasture, (2) the relative efficiency of 2 per cent corn and 2 per cent ground-barley rations as supplements to alfalfa pasture, and (3) the carrying capacity of alfalfa pasture when no supplement is fed.

The alfalfa pastured in these experiments was seeded on April 6, 1912, hay having been harvested from the plats during the seasons of 1912 and 1913. The yields of the different plats during these years were very uniform. Figure 2 gives a view of the alfalfa pasture used in this experiment. The hogs used during the first period were a very inferior lot. They were a mixture of several breeds, ranging from high-grade Berkshires to scrubs and varying in size from 50 to 160 pounds.

These hogs were put on alfalfa pasture, with a small ration of grain, for about a week after they were received at the farm. They were then weighed, ear tagged, and divided into lots which were as uniform as possible. The mean of three consecutive days' weighing was taken as the initial weight. Each hog was weighed separately and individual weights were kept of each throughout the experiment. Lot 1 received no grain; lot 2 received a 1 per cent ration of corn: lot 3 received 2 per cent corn; lot 4, 2 per cent barley; and lot 5, 3 per cent corn.

Shortly after the beginning of the first period an outbreak of cholera occurred. Treatment was applied as soon as possible, but the disease did enough damage to affect the results of the test. Nevertheless, fair returns were secured, the net returns per acre of alfalfa pasture from May 3 to July 2 ranging from $18.76, where no supplement was fed, to $54.19, where the pasture was supplemented with a 3 per cent ration of corn.

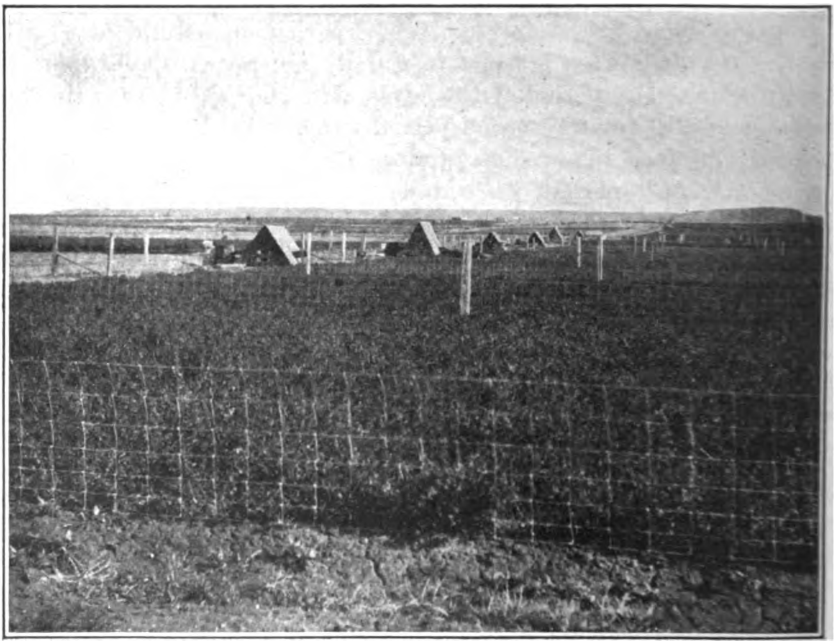

FIG. 2.—The alfalfa plats used in 1914 and 1915 in the hog-pasturing experiments at the Scottsbluff Experiment Farm, showing the portable houses and the method of dividing the pastures.

The plan was to use spring-farrowed pigs during the second period of the experiment, but, as a great many of the spring pigs had died from cholera, it was necessary to select the best of the smaller hogs that had been used during the first period. No hogs, however, were used from the two lots which had had no grain and 1 per cent corn.

respectively. The hogs used were good, thrifty stock, but were not uniform in size, varying from 15 to over 100 pounds in weight. The majority weighed about 45 pounds. They were divided into lots and turned on the alfalfa pasture on July 8. The results obtained in the first period showed that the hogs which were fed grain consumed less alfalfa than those which received no grain. For this reason the number of hogs in the lots in the second period was increased in accordance with the grain fed. The average weights of the hogs in the different lots were fairly uniform, at about 58 pounds. During the first two weeks of the period it was necessary to replace six pigs which developed cholera symptoms. Owing to these changes, the average initial weight per pig in lots 1 and 5 was somewhat higher than the average weight per pig in the other lots.

As the hogs were weighed only every 15 days, and as the grain ration was based on the initial weight at the beginning of each 15-day period, with a gradual increase to cover the estimated daily gain, it is apparent that the hogs might be fed slightly more or less than the quantity planned, but the difference was small. At the end of the experiment the total amount of grain actually fed was ascertained to have been as follows: Lot 2 was fed 1.1 per cent corn; lot 3 was fed 2.06 per cent corn; lot 4 was fed 1.93 per cent ground barley; and lot 5 was fed 2.64 per cent corn. Lot 1 received no grain.

There were seven pigs, weighing a total of 396 pounds, in lot 1 at the beginning of the experiment. One pig died at the end of the second month, and on August 22, when the plat was becoming overpastured, a hog weighing 120 pounds was taken out. On September 9, when the growth of the alfalfa had become very slow, four more pigs were taken off the plat. The total gain made by the pigs in this lot from July 8 to October 6 was 102 pounds, or 408 pounds per acre. In lot 2 there were eight pigs, with a total initial weight of 516 pounds. On August 22 one pig weighing 119 pounds, and on September 9 five more pigs, weighing a total of 391 pounds, were removed because the pasture was becoming overgrazed. This lot made a total gain of 252 pounds from the quarter acre of alfalfa and 495 pounds of corn. In lot 3, which was fed 2 per cent corn, there were 10 pigs, with a total initial weight of 573 pounds. On August 22 one pig, weighing 126 pounds, was taken out, and September 9 six more, weighing a total of 573 pounds, were removed, leaving three pigs with a combined weight of 305 pounds. This lot was fed 1,162 pounds of corn and made a total gain of 475 pounds. In lot 4, which was fed 2 per cent barley, there were 10 pigs, having a total initial weight of 561 pounds. To avoid overpasturing the plat, one pig, weighing 92 pounds, was removed on August 22, and six pigs, weighing a total of 439 pounds, were removed on September 9. This lot was fed 1,058 pounds of barley during the period and made 435 pounds of gain. In lot 5, which was fed 3 per cent corn, there were 11 pigs, having a total initial weight of 771 pounds. Owing to shortage of pasture, one pig weighing 135 pounds was removed August 22. On September 9 six more pigs, with a total weight of 589 pounds, were removed. Lot 5 was fed 2,202 pounds of corn during the period and made a total gain of 735 pounds. The experiment closed on October 6.

Table III shows the combined results of the two periods of 1914, calculated to an acre basis. The results for the first period were not what could be expected under favorable conditions, since the hogs used were rather inferior and the outbreak of cholera did some damage. The hogs used during the second period were fairly good stock and the results should be fairly dependable. It is thought also that the combined results of the two periods give a reliable indication of the effects of feeding different quantities of grain, as well as showing what was possible under the conditions that prevailed.

TABLE III.—*Results obtained by feeding five lots of hogs on alfalfa pasture, supplemented with varying quantities of grain, at the Scottsbluff Experiment Farm during two periods in 1914.*

| Items of comparison. | Lot 1, no grain. | Lot 2, 1 per cent corn. | Lot 3, 2 per cent corn. | Lot 4, 2 per cent barley. | Lot 5, 3 per cent corn. |
|---|---|---|---|---|---|
| Total gain per acre..........pounds.. | 676 | 1,520 | 3,036 | 2,780 | 4,416 |
| Average daily gain per acre..........do.... | 4.33 | 9.75 | 19.46 | 17.82 | 28.30 |
| Grain fed..........do.... | None. | 3,595 | 8,266 | 7,744 | 13,352 |
| Grain per pound of gain..........do.... | .......... | 2.36 | 2.72 | 2.78 | 3.02 |
| Gain per 100 pounds of grain..........do.... | .......... | 42.3 | 36.8 | 36.0 | 33.1 |
| Financial statement: | | | | | |
| Net returns per acre of pasture.......... | $47.32 | $67.93 | $124.07 | $117.16 | $168.25 |
| Daily net returns per acre of pasture.......... | .30 | .43 | .81 | .75 | 1.08 |
| Net returns for 100 pounds of grain (pasture at $47.32 per acre).......... | .......... | 1.64 | 2.00 | 1.91 | 1.96 |
| Cost per 100 pounds of gain.......... | 2.22 | 3.52 | 3.41 | 3.32 | 3.61 |
| Equivalent paid for hay, per ton.......... | 7.22 | 13.38 | 19.21 | 17.86 | 25.30 |

Table III shows the total and daily gains for each lot of hogs from May 3 to October 6, a period of 156 days. The gains varied with the amount of grain fed. Lot 1 made 676 pounds of gain; lot 2, 1,520 pounds; lot 3, 3,036 pounds; lot 4, 2,780 pounds; and lot 5, 4,416 pounds. The daily gains per acre as shown in Table III varied from 4.33 pounds in lot 1, which received no grain, to 28.3 pounds in lot 5, which received approximately a 3 per cent ration of corn. Lot 5 made 3,740 pounds more gain per acre than lot 1. Lot 5 was fed 13,352 pounds of corn, while lot 1 received no grain. The 3,750 pounds of gain, therefore, can be credited to the use of 13,352 pounds of corn; that is to say, each 100 pounds of corn fed resulted in the production of 28 pounds of pork, whereas when hogs are fed corn alone 18 pounds per 100 pounds of corn is considered a satisfactory gain. The hogs in lot 5 paid $1.96 per hundredweight for the corn fed. By this method of calculation it can be shown that lot 2 paid $1.64, lot 3, $2, and lot 4, $1.91 per hundredweight for the grain fed.

The quantity of grain required with alfalfa pasture to produce a pound of pork varied from 2.36 pounds in lot 2 to 3.02 pounds in lot 5, the quantity increasing with the total quantity of grain fed. The cost per 100 pounds of gain varied from $2.22 in lot 1 to $3.61 in lot 5. The total and daily net return per acre of alfalfa pasture increased with the amount of grain fed. Lot 1, with no grain, paid $47.32 an acre for the alfalfa pasture. This was much more than the hay crop would have sold for in the stack had it been harvested. This partly explains why many farmers are content to carry hogs through the summer on alfalfa pasture with little or no grain. After paying for the grain fed, lot 2 paid $67.93; lot 3, $124.07; lot 4, $117.16; and lot 5, $166.25 per acre of alfalfa pasture for the season. The daily net returns per acre of alfalfa increased from 30 cents where no grain was fed to $1.06 where about 3 per cent of corn was fed.

Five plats of alfalfa in the same field where these experiments were conducted yielded at the rate of 6.56 tons of hay per acre in four cuttings. On the basis of this yield, if the cost of harvesting the hay crop is equal to the cost of caring for the hogs, lot 1 paid $7.22 a ton for alfalfa hay; lot 2 paid $13.38; lot 3, $19.21; lot 4, $17.86; and lot 5, $25.30. The manure left on the land is also of some value and should be considered in favor of the practice of pasturing hogs on alfalfa.

### EXPERIMENTS IN 1915.

The 1914 pasturing experiments were repeated during the summer of 1915, with the addition of one more lot (3*a*) fed 2 per cent corn. These pasturing experiments were conducted on the same alfalfa plats that were used in 1914, with the exception of one, lot 3*a*, which was on third-year alfalfa. The same general plan was followed in 1915 as in 1914, as described above.

The 1915 season was very backward and suffered many disadvantages. The hogs were put on pasture on April 26. The first two weeks the hogs did well, but on May 18 a foot of snow fell and the temperature dropped to 29° F. This made it necessary to remove the hogs from the plats for seven days, during which time each lot was kept separately and fed the regular amount of grain. Again, on August 6, a severe hailstorm did a great deal of damage to the alfalfa. The damage done on the pasture plats was not as great as on the plats which were left for hay. There is little doubt that the hogs obtained more feed from the pastured plats than was harvested from the others. In 1914 the average yield from the harvested plats was 6.53 tons and in 1915 only 4.47 tons per acre. The hogs used in the experiments during 1915 were of very much better quality than those used in 1914. This may explain why the returns in 1915, notwithstanding the damage done to the alfalfa, were equal to those of 1914.

The first period extended from April 26 to June 30, or a total of 60 days. The shotes used were farrowed during the fall and late summer of the previous year and weighed an average of 108 pounds when the experiment began. The pigs used during the second period, which began June 30, were pure-bred Duroc-Jerseys. They were reared on the experiment farm, where they were farrowed during April and the early part of May. They weighed an average of 33 pounds when the experiment began. Though small, they were in good, thrifty condition. When the cool weather of autumn came on, the alfalfa made less growth, which made it necessary to take out hogs at different times. The experiment closed September 27.

Notwithstanding the fact that the summer of 1915 was very backward and cool, the returns from alfalfa pastures were practically the same as in 1914. The hogs used in 1915 were smaller and a very much better class of stock than those used in 1914, when returns from the first period were reduced by cholera. Better stock and freedom from sickness in 1915 apparently offset the low yield of alfalfa in that year. The second period in 1915 gave higher returns for both grain and pasture, and also cheaper gains than were secured in the first period. It is generally true that the smaller the hogs, other things being equal, the more economical the gains.

A summary of the results of the two periods of 1915 is given in Table IV, in which the data have been calculated to an acre basis.

TABLE IV.—*Results obtained by feeding six lots of hogs on alfalfa pasture, supplemented with varying quantities of grain, at the Scottsbluff Experiment Farm during two periods in 1915.*

| Items of comparison. | Lot 1, no grain. | Lot 2, 1 per cent corn. | Lot 3, 2 per cent corn. | Lot 3a, 2 per cent corn. | Lot 4, 2 per cent barley. | Lot 5, 3 per cent corn. |
|---|---|---|---|---|---|---|
| Total gain per acre...............pounds.. | 612 | 1,456 | 2,976 | 2,760 | 2,772 | 4,[illegible] |
| Average daily gain per acre.........do.... | 4.0 | 9.5 | 19.3 | 17.9 | 18.0 | 27.9 |
| Grain fed...........................do.... | None. | 2,752 | 7,048 | 6,796 | 6,728 | 12,168 |
| Grain per pound of gain............do.... | .......... | 1.89 | 2.53 | 2.46 | 2.43 | 2.83 |
| Gain per 100 pounds of grain........do.... | .......... | 53.0 | 39.5 | 40.7 | 41.1 | 35.3 |
| Financial statement: | | | | | | |
| Net returns per acre of pasture........ | $42.84 | $72.48 | $132.91 | $120.49 | $126.76 | $170.24 |
| Daily net returns per acre of pasture... | .28 | .47 | .86 | .78 | .82 | 1.10 |
| Net returns for 100 pounds of grain (pasture at $42.84 per acre).......... | .......... | 2.14 | 2.20 | 2.21 | 2.23 | 2.11 |
| Cost per 100 pounds of gain (pasture at $15 per acre)....................... | 2.45 | 3.06 | 3.04 | 3.17 | 2.97 | 3.35 |
| Equivalent paid for hay, per ton...... | 9.58 | 16.21 | 29.54 | 26.95 | 28.13 | 35.65 |

For the entire season of 1915, as shown in Table IV, the gains per acre were as follows: Lot 1, 612; lot 2, 1,456; lot 3, 2,976; lot *3a*, 2,760; lot 4, 2,772; and lot 5, 4,292 pounds. The lot that was fed 3 per cent corn made seven times as much gain as the lot which received no grain. The grain consumed for each pound of gain increased with the grain ration. It required 1.5 times as much grain for each pound of gain where a 3 per cent corn ration was fed as it did where only a 1 per cent corn ration was fed. For every 100 pounds of grain fed the 1 per cent corn lots gained 53 pounds; the average of the 2 per cent grain lots was 40.4 pounds; and the 3 per cent corn lots gained 35.3 pounds.

When the gains made are figured at $7 per hundredweight and the lots charged $1.07 per hundredweight for corn and $1 for ground barley, the net returns per acre for alfalfa pasture were as follows: Lot 1, $42.84; lot 2, $72.48; lot 3, $132.91; lot *3a*, $120.49; lot 4, $126.76; and lot 5, $170.24. From April 26 to September 27, a period of 154 days, the hogs gave an average daily net return ranging from 28 cents, where no grain was fed, to $1.10, where 3 per cent corn was fed. At this rate a 10-acre alfalfa field pastured with hogs getting a 3 per cent ration of corn would pay $11 net per day, whereas if no grain was fed the same 10-acre field would return only $2.80 per day. The no-grain lot paid at the rate of $42.84 an acre for alfalfa pasture. When the grain-fed lots are charged the same amount for the pasture, they still paid very liberally for the grain fed, as is shown in Table IV.

The equivalent paid for hay by the different lots greatly increased with the grain ration. The no-grain lot returned an equivalent of $9.58; the 1 per cent lot, $16.21; the average of the 2 per cent grain lots, $28.21; and the 3 per cent grain lot paid $38.07 per ton, or four times as much as the no-grain lot. This fact, together with the high price paid for the grain, emphasizes the advisability of feeding grain in connection with alfalfa pasture in order to realize the highest return from both the grain and the alfalfa crops.

### SUMMARY OF THE TWO YEARS' RESULTS.

The results of the experiments in 1914 and 1915 with alfalfa pasture and various grain supplements are summarized in Table V. As two lots of hogs were used each year in each part of the test, the figures in Table V show the average of the results secured from four lots of hogs in each instance. The figures have been calculated to an acre basis.

The results of two years' work show that hogs on alfalfa pasture without grain produced an average of 644 pounds of gain per acre. The same area of pasture, with the addition of 3,174 pounds of corn, produced 1,488 pounds of gain. Where 7,657 pounds of corn was fed the gain was 3,006 pounds; where 7,236 pounds of ground barley was fed the gain was 2,776 pounds, and where 12,760 pounds of corn supplemented the alfalfa pasture, the gain was 4,354 pounds per acre of pasture. With this information the farmer can apply prices that suit his own particular condition and determine the most economical quantity of grain to feed.

TABLE V.—*Results obtained by feeding hogs on alfalfa pasture, supplemented with varying quantities of grain, at the Scottsbluff Experiment Farm in 1914 and 1915.*

| Items of comparison. | Lot 1, no grain. | Lot 2, 1 per cent corn. | Lot 3, 2 per cent corn. | Lot 4, 2 per cent barley. | Lot 5, 3 per cent corn. |
|---|---|---|---|---|---|
| Total gain per acre........................pounds.. | 644 | 1,488 | 3,006 | 2,776 | 4,354 |
| Average daily gain per acre ....................do.... | 4.1 | 9.6 | 19.3 | 17.9 | 28.0 |
| Grain fed.........................................do.... | .......... | 3,174 | 7,657 | 7,236 | 12,760 |
| Grain per pound of gain.........................do.... | .......... | 2.11 | 2.63 | 2.61 | 2.93 |
| Gain per 100 pounds of grain..................do.... | .......... | 47.4 | 38.0 | 38.3 | 34.1 |
| Financial statement: | | | | | |
| Net returns per acre of pasture.................. | $45.08 | $70.20 | $128.49 | $121.96 | $168.25 |
| Daily net returns per acre of pasture............ | .29 | .45 | .83 | .79 | 1.08 |
| Net returns for 100 pounds of grain (pasture at $45.08 per acre)........................................ | .......... | 1.86 | 2.16 | 2.06 | 2.03 |
| Cost per 100 pounds of gain (pasture at $15 per acre)........................................ | 2.33 | 3.29 | 3.22 | 3.14 | 3.48 |
| Equivalent paid for hay, per ton................ | 8.16 | 12.71 | 23.25 | 22.10 | 30.48 |

Two years' results show that more pasture is required when no grain is fed and that as the grain ration is increased the area of pasture required is decreased. The areas required when no grain, 1 per cent grain, 2 per cent grain, and 3 per cent grain were fed were approximately as 5, 4, 3, and 2, respectively.

For every 100 pounds of grain fed, lot 2 made 47.4 pounds of gain; lot 3, 38 pounds; lot 4, 38.3 pounds; and lot 5, 34.1 pounds. The higher the grain ration the lower the gains per unit of grain fed. Also, the lower the grain ration the more pasture was required for 100 pounds of gain.

With the prices here used, the two-year average net return per acre of alfalfa pasture were as follows: No-grain lot, $45.08; 1 per cent corn lot, $70.20; 2 per cent corn lot, $128.49; 2 per cent ground barley lot, $121.96; and the 3 per cent corn lot, $168.25. The average daily net return per acre for 154 days ranged from 29 cents, where no grain was fed, to $1.08, when a 3 per cent ration of corn was fed.

The two-year average net return per acre of alfalfa pasture from lots 3 and 4 show the sum of $6.43 in favor of corn over ground barley. It will also be seen from Table V that the corn lot was fed a little more grain than the barley lot. Higher returns would, therefore, be expected from the corn-fed lot, as the results have shown that the net returns for pasture increase with the grain ration. The difference in net returns, therefore, is not enough to warrant the statement that corn at $1.07 per hundredweight is cheaper feed than ground barley at $1 per hundredweight. The average of the two years' results, and especially the 1915 results, seems to indicate very strongly that, pound for pound, ground barley is approximately equal to corn as feed for hogs in supplementing alfalfa pasture.

The two-year average net return for alfalfa pasture was $45.08 where no grain was fed. If the grain-fed lots are charged this amount for pasture, the net returns for each 100 pounds of grain fed were as follows: 1 per cent corn lot, $1.86; 2 per cent corn lot, $2.16; 2 per cent barley lot, $2.06; and the 3 per cent corn lot, $2.03. It appears from this that 2 pounds of corn per day for each 100 pounds of live weight is the most satisfactory ration of corn for hogs on alfalfa pasture in order to get the highest return from both the corn and alfalfa pasture. This is true when the feeder can get only a limited amount of corn, but when an abundant supply of corn is available at not more than $1.07 per hundredweight, it may be desirable to feed about 3 pounds of corn to each 100 pounds of live weight. Hogs fed a 3 per cent ration of corn will make a faster growth than those fed a 2 per cent ration and hence be ready for the market earlier. As a saving of time lessens risk and also saves interest on investment, this is a factor to be considered. Figure 3 shows a representative hog from the lot getting no grain, and one each from lots getting 1 per cent, 2 per cent, and 3 per cent of corn in 1914.

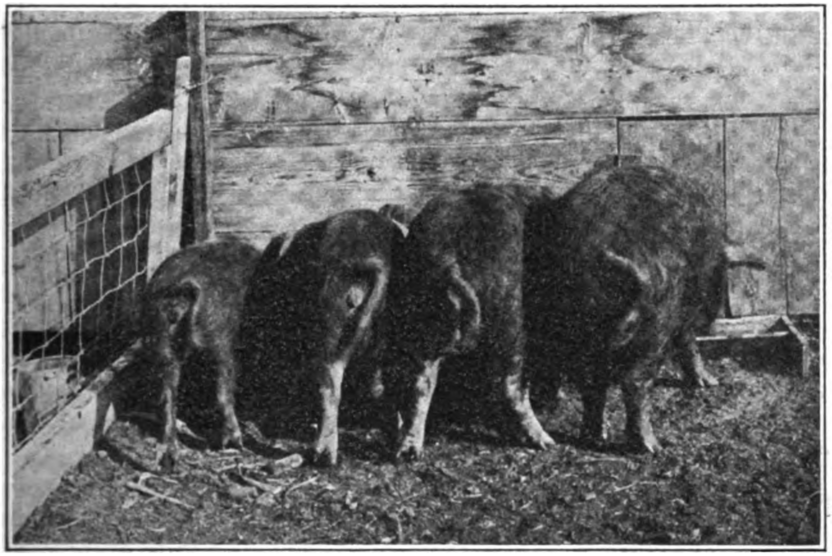

FIG. 3.—Representative hogs from the lots fed varying grain supplements on alfalfa pasture at the close of the second period in 1914. From left to right: No grain, 1 per cent corn, 2 per cent corn, and 3 per cent corn.

When a charge of $15 per acre is made for the alfalfa pasture, the total cost per 100 pounds of gain was as follows: No-grain lot, $2.33; 1 per cent corn lot, $3.29; 2 per cent corn lot, $3.22; 2 per cent barley lot, $3.14; and the 3 per cent corn lot, $3.48. The no-grain lot made gains for $1.15 per hundredweight less than the 3 per cent corn lot did. It might appear from this that to pasture hogs on alfalfa without grain is the best practice, but this is not generally true, because of the much smaller returns of pork per acre.

Perhaps the most impressive thing shown in Table V is the amount paid for hay and its very rapid increase with the increase in the grain rations. The 2-year average yield of alfalfa hay from the check plats was 5.52 tons per acre. On this basis and assuming that the care of the hogs is equal to the cost of harvesting the hay, the no-grain lot paid an equivalent of $8.16; the 1 per cent grain lot paid $12.71; the 2 per cent grain lots, an average of $22.67, and the 3 per cent grain lot, $30.48 a ton for alfalfa.

It seems certain that it will pay the farmer to feed hogs on alfalfa pasture at least 2 pounds of corn daily per 100 pounds of live weight. By so doing he will not only get a higher return from his alfalfa, but he may expect also to make a profit on the corn fed. According to these results, it requires less capital for the same net return where grain is fed than where no grain is fed. When a 3 per cent corn ration is fed with alfalfa pasture, 1 acre will produce as much pork as 6.5 acres of alfalfa without grain, or a saving of 5.5 acres of land. Again, when fed a 3 per cent corn ration with alfalfa pasture, 52 pigs will make as much pork as 156 pigs on alfalfa pasture alone.

### ALFALFA PASTURE FOR SOWS AND LITTERS.

The following is a discussion of the results obtained by pasturing sows and their litters on alfalfa pasture. The first experiment began in the spring of 1914, as soon as the alfalfa was large enough to pasture, and continued 60 days. There were two sows and their pigs in each lot. During the first month and a half the quarter-acre plat furnished plenty of pasture, but after that time the pigs were so large that the pasture could not carry them all. When the pigs were large enough to wean, one or both of the sows were removed to prevent overpasturing.

The sows and pigs were fed daily approximately 2 pounds of corn for each 100 pounds of the weight of both sows and pigs. At first the grain was fed to the sows only, but later, when the pigs began to eat, they were fed separately. A small opening was made in the dividing fence, so that the pigs could go from one half of the pasture to the other. Both sows and pigs were fed twice daily, morning and evening. There are two ways of looking at the results of these experiments. One is to charge the pigs with only the feed and the other is to charge the pigs with both feed and the loss in weight of the sows. The second method is used here.

In 1914 two sows and 14 pigs were put on the alfalfa pasture plat on May 4. On this date the two sows weighed a total of 702 pounds and the 14 pigs a total of 164 pounds. The experiment closed on July 3. At this date one sow still remained on the plat, while the other one had been taken off on June 19. The final weight of the two sows was 603 pounds, or 99 pounds less than the initial weight. The 14 pigs weighed a total of 636 pounds. They had increased in weight 472 pounds in 60 days. The total initial weight of the sows and pigs was 866 and their total final weight 1,239 pounds, or a total increase of 373 pounds for the lot. The lot was fed 1,176 pounds of corn. The 373 pounds gain at $7 per hundredweight is worth $26.11. Deducting from this the cost of 1,176 pounds of corn at $1.07 per hundredweight, or $12.58, leaves a return of $13.53 for one-fourth acre of alfalfa pasture for 60 days, or a daily return of 90 cents per acre. The sows and pigs ate 3.02 pounds of corn for each pound of net gain. With corn at $1.07 per hundredweight and alfalfa pasture at $7 an acre for 60 days, 100 pounds of gain cost $3.83. This lot paid the equivalent of $19.02 a ton for alfalfa hay. A tabulated statement of this lot is given in the first column of Tables VI and VII.

In the 1915 tests, which began April 27 and ended June 26, there were three lots of two sows and litters each. One lot was fed ground barley and the other two lots were fed corn. They were fed grain at the rate of about 2 pounds daily for each 100 pounds of live weight. In two of the lots old sows were used and in the other gilts were used. The total initial weight of lot 6, which received ground barley, was 760 pounds. The sows weighed 702 and the 17 pigs 58 pounds. One sow was taken off on June 9. The other remained until the close of the experiment. The total final weight was 1,178 pounds, or a total gain of 418 pounds. The sows lost 28 pounds and the pigs gained 446 pounds. A total of 982 pounds of ground barley was fed to this lot. From each 100 pounds of grain fed this lot produced 42.5 pounds of gain. After paying $1 per hundredweight for the barley fed, the lot still paid at the rate of $1.30 daily for an acre of alfalfa pasture. In lot 7, which was fed corn, the initial weight of the two sows was 873 pounds and of the 15 pigs 83 pounds, or a total of 956 pounds. The old sows were taken off the plat on June 9. At this date they weighed 780 pounds, or 93 pounds less than they did when the experiment began. The final weight of the pigs was 574 pounds, their increase being 491 pounds. The total increase in weight of the lot was 398 pounds.

This lot was fed 1,098 pounds of corn. For each 100 pounds of corn fed this lot gained 36.2 pounds. The daily net return per acre of pasture was $1.09. In lot 8, which also received corn, the sows were gilts and were much lighter than the old sows in the other two lots. At the beginning of the experiment the two sows weighed 468 pounds, and when taken off the plat on June 9 they weighed 430 pounds, a loss of 38 pounds. The initial weight of the 15 pigs was 118 pounds and the final weight 541 pounds. The total gain of the lot was 385 pounds. While on pasture this lot was fed 884 pounds of corn, the lot producing 43.8 pounds of gain per 100 pounds of grain. On an acre basis, the daily net return for pasture was $1.17.

The initial and final weights for both sows and pigs, with their loss or gain, and the amount of grain fed for the 1914 lot and the three 1915 lots are given in Table VI.

TABLE VI.—*Weights of the sows and pigs and the amount of grain fed while on one-fourth of an acre of alfalfa pasture for 60 days, at the Scottsbluff Experiment Farm in 1914 and 1915.*

| Items of comparison. | 1914 | 1915 | | |
|---|---|---|---|---|
| | Corn. | Lot 6, 2 per cent barley. | Lot 7, 2 per cent corn. | Lot 8, 2 per cent corn. |
| Number of sows | 2 | 2 | 2 | 2 |
| Number of pigs | 14 | 17 | 15 | 15 |
| Initial weight of sows ........ pounds | 702 | 702 | 873 | 468 |
| Initial weight of pigs ........ do | 164 | 58 | 83 | 118 |
| Final weight of sows ........ do | 603 | 674 | 780 | 430 |
| Final weight of pigs ........ do | 636 | 504 | 574 | 541 |
| Loss by sows ........ do | 99 | 28 | 93 | 38 |
| Gain by pigs ........ do | 472 | 446 | 491 | 423 |
| Net gains ........ do | 373 | 418 | 398 | 385 |
| Grain fed ........ do | 1,176 | 982 | 1,098 | 884 |

As shown in Table VI, the pigs used in 1914 were much larger than those used in 1915, the former being older than the latter. If the lot had not been charged with the loss in weight of the sows, the results would have been still more favorable, especially in the 1914 lot and in lot 7. In these two lots, for some reason, the sows lost much more than in the other two lots. More complete data obtained from pasturing sows and their litters on alfalfa in 1914 and 1915 are given in Table VII, in which the results have been computed to an acre basis.

As shown in Table VII, the net returns were higher in 1915 than in 1914. The average of the four lots shows that it required 2.62 pounds of grain with alfalfa pasture to produce 1 pound of gain, or for every 100 pounds of grain fed the sows and pigs gained 38.2 pounds. The average net return per acre of alfalfa pasture for 60 days was $66.84, or a daily net return of $1.11. The lowest net return for the pasture was $54.11 and the highest $77.76. This highest net return was obtained from the lot fed ground barley.

TABLE VII.—*Results obtained by feeding sows and their litters on alfalfa pasture, supplemented with a 2 per cent ration of grain, at the Scottsbluff Experiment Farm in 1914 and 1915.*

| Items of comparison. | 1914, 2 per cent corn. | 1915 | | | 1914 and 1915, average of 4 lots. |
|---|---|---|---|---|---|
| | | Lot 6, 2 per cent barley. | Lot 7, 2 per cent corn. | Lot 8, 2 per cent corn. | |
| Number of sows and litters | 8 | 8 | 8 | 8 | 8 |
| Average number of pigs per litter | 7 | 8.5 | 7.5 | 7.5 | 7.62 |
| Average initial weight of pigs ....pounds.. | 11.71 | 3.41 | 5.53 | 7.90 | 6.95 |
| Average final weight of pigs ....do.... | 45.4 | 29.6 | 38.2 | 36.1 | 37.0 |
| Total gain per acre ....do.... | 1,492 | 1,672 | 1,592 | 1,540 | 1,574 |
| Average daily gain for lot ....do.... | 24.9 | 27.9 | 26.5 | 25.7 | 26.2 |
| Total grain fed ....do.... | 4,704 | 3,928 | 4,392 | 3,536 | 4,140 |
| Grain per pound of gain ....do.... | 3.15 | 2.35 | 2.76 | 2.28 | 2.62 |
| Gain per 100 pounds of grain ....do.... | 31.7 | 42.5 | 36.2 | 43.8 | 38.2 |
| Financial statement: | | | | | |
| Net returns per acre of pasture | $54.11 | $77.76 | $65.52 | $69.97 | $66.84 |
| Daily net returns per acre of pasture | .90 | 1.30 | 1.09 | 1.17 | 1.11 |
| Cost per 100 pounds of gain (pasture at $7 per acre). | 3.83 | 2.76 | 3.32 | 2.91 | 3.21 |
| Equivalent paid for hay, per ton | 19.02 | 37.74 | 31.80 | 33.96 | 30.63 |

If the sows and pigs are charged $7 per acre for 60 days' use of alfalfa pasture, $1.07 per hundredweight for corn, and $1 per hundredweight for barley, each 100 pounds of gain cost an average of $3.21. The gains on the 1914 lot cost $3.83 per hundredweight, while the gains on lot 6 (barley) in 1915 cost only $2.76.

The average yield of similar plats of alfalfa during these pasturing periods was 2.85 tons in 1914 and 2.06 tons in 1915. If it is assumed that the pastured plats would have yielded the same, the four lots paid an average of $30.63 a ton for alfalfa hay and the hogs did the harvesting themselves. Moreover, by pasturing the alfalfa it may be assumed that the fertility of the soil was somewhat increased.

## HOGGING CORN.

The experiments which have been conducted with different methods of hogging corn fall into two classes: (1) Those in which no supplement was fed with the corn and (2) those in which the hogs were provided with some nitrogenous feed while they were in the cornfield. Experiments in which no supplements were used have been conducted for four years and the others for two years.

### CORN WITHOUT SUPPLEMENTARY FEED.

Each year in the irrigated crop-rotation field, a quarter-acre plat of corn in a 6-year rotation is fenced and the hogs are turned into it to harvest the crop. This experiment began in 1912 and has been continued each year. The hogs are turned into the corn when it is well "dented," usually about September 10. As no supplementary feed is supplied and as the weeds and volunteer alfalfa are kept down, the gains secured are made from corn alone. Each year since 1912 the corn has been grown on land which had produced alfalfa the previous year. This explains the difference in yields, as will be indicated later.

In 1912 seven hogs were used in the test, one old sow weighing 384 pounds and six shotes with an average weight of 72 pounds. The hogs were on the plat 16 days. When removed the lot weighed 974 pounds, the total gain having been 157 pounds. The sow made a daily gain of 1.44 pounds, while each shote, weighing less than one-fifth as much as the sow, gained 1.24 pounds per day. In other words, the sow made 0.6 per cent daily gain and the pigs made 1.51 per cent daily gain. The average yield of five similar quarter-acre plats of corn in the same field was 795 pounds. If it is assumed that the hogged plat yielded the same as this average, the hogs paid $1.38 per hundredweight for the corn in the field.

Six thrifty shotes, averaging 92 pounds each, were used in 1913. These shotes had been on alfalfa pasture with a 2.3 per cent ration of corn during the summer. The shotes were on the corn plat 28 days. When they were taken off they weighed 800 pounds, having gained 253 pounds. The corn yield was estimated at 1,154 pounds. On this basis the hogs paid $1.53 per hundredweight for the corn.

The six hogs used to harvest the corn plat in 1914 were thin and small. During the summer two had been on alfalfa pasture without grain and four on alfalfa pasture with a 1 per cent corn ration. Their total initial weight was 380 pounds and their total final weight was 642 pounds. The hogs were on the corn plat 49 days and gained 262 pounds. The yield of the corn plat was estimated at 1,142 pounds. On this basis the hogs paid $1.60 per hundredweight for the corn in the field.

Three shotes, with a total initial weight of 224 pounds, were used in 1915. Their final weight, after they had been on the plat for 19 days, was 277 pounds, the gain being 53 pounds. This poor return was due to the fact that the corn plat was almost completely hailed out. The yield of the plat was estimated at 370 pounds. In this test, if the estimated yield is correct, it required 694 pounds of corn to produce 100 pounds of gain and this gain cost $7.43.

The results of the four years' tests, computed to an acre basis, are given in Table VIII. These results are not strictly comparable, as there were two varying factors. The average initial weight of the hogs varied from 117 pounds in 1912 to 63 pounds in 1914, and the number of days that the hogs were on the corn varied from 16 in 1912 to 49 in 1914. Small shotes will make more gain than larger hogs from a given quantity of feed. Hogs that have just been taken from alfalfa pasture will make very good gains for a short period on corn alone, but when fed corn alone for a long period the gains are not so good. In other words, 100 pounds of corn will make more gain on hogs the first week after the hogs are taken off alfalfa pasture than the same amount of corn will when fed to hogs that have been on corn alone for several weeks. As will be seen from Table VIII, these two variable factors were in direct opposition to each other; that is, the larger the hogs the shorter the feeding period. As the corn crop in 1915 was seriously affected by hail, the results of that year are not included in the average shown in Table VIII, but they are shown in the last column of the table as a matter of record.

TABLE VIII.—*Results of hogging corn without supplementary feed at the Scottsbluff Experiment Farm in 1912, 1913, 1914, and 1915.*

| Items of comparison. | 1912 | 1913 | 1914 | 3-year average. | 1915 |
|---|---|---|---|---|---|
| Number of hogs per acre | 28 | 24 | 24 | 23 | 12 |
| Number of days | 16 | 28 | 49 | 31 | 19 |
| Average initial weight ... pounds | 117 | 91 | 63 | 90 | 75 |
| Average final weight ... do | 139 | 133 | 107 | 126 | 92 |
| Total gain per acre ... do | 628 | 1,012 | 1,048 | 896 | 212 |
| Estimated yield of corn ... bushels | 56.1 | 82.6 | 81.9 | 76.87 | 26.2 |
| Gain per 100 pounds of corn ... pounds | 20.0 | 21.8 | 22.6 | 21.5 | 14.5 |
| Financial statement: | | | | | |
| Value of gains per acre | $42.96 | $70.84 | $73.36 | $65.72 | $14.84 |
| Returns for 100 pounds of corn | 1.38 | 1.53 | 1.60 | 1.50 | 1.00 |
| Cost per 100 pounds of gain (corn at $1.07 per hundredweight) | 5.36 | 4.81 | 4.67 | 4.95 | 7.43 |

A short hogging period is objectionable from an experimental standpoint because there are more chances of error. For example, if the hogs are gaunt at either the initial or final weighing, 20 hogs on a corn plat for 1 week will give a larger error than 2 hogs on the same plat for 10 weeks. The mean weight of three consecutive days' weighing will not entirely eliminate this error, especially if the hogs are left on the corn plat too long and are gaunt at the final weighing. Just how much each of these factors influenced the results shown in Table VIII is uncertain. There is little doubt that the low returns per bushel of corn in 1912 were due to the fact that the large sow was in the lot. The low total gains and net returns per acre in 1912, however, were due largely to the low yield of corn, it having been estimated at 56.1 bushels per acre, as compared with 82.6 and 81.9 bushels, respectively, for the two succeeding years. In computing the cost of 100 pounds of gain, a charge of $1.07 per hundredweight was made for the corn. The results show that this method of utilizing corn has much to recommend it.

### CORN WITH SUPPLEMENTARY FEED.

To secure information regarding the value of tankage and of alfalfa pasture as supplements to corn when hogged off, an experiment was conducted in duplicate in 1914 and 1915. Six lots of hogs were used each year, as follows: Lots 1 and 2, hogged corn alone; lots 3 and 4, hogged corn and had access to an alfalfa field; and lots

5 and 6, hogged corn and had what tankage they would eat. The shotes used in this experiment had been in the alfalfa pasturing experiment and were very uniform in size, as will be seen from the weights given in Table IX.

Both years the cornfield to be hogged was divided into six separate fields of one-third acre each by a fence of 26-inch hog wire between the corn rows. The cornfield used in 1914 was located on a break of high land, where in places the gravel came near the surface, causing some differences in the yield of the different plats. The plats used in 1915 were more uniform, but the corn, owing to hail and frost, was not as good as the corn that was hogged the year before.

Each year the yield of each plat was estimated by counting all the stalks of corn and harvesting systematically the corn from 100 stalks: that is to say, if a plat had a total of 3,400 stalks, the corn was harvested from every thirty-fourth stalk. The harvested corn was dried, weighed, and returned to the plat to be eaten by the hogs. The total weight was divided by 100, to get the average yield per stalk harvested. This average weight was then multiplied by the total number of stalks on the plat in order to get the yield.

As the low-yielding plats became cleaned up, weighed quantities of corn were added, so that all the hogs would be kept on feed the same length of time. Enough corn was added as became necessary so that the hogs had corn before them all the time. When the last lot had cleaned up its plat the experiment was closed. In 1914 the hogs were in the corn plats from September 9 to November 25, a period of 77 days. The 1915 test began October 6 and closed November 30, covering a period of 55 days.

The hogs were watered twice a day. Lots 5 and 6 were fed tankage when they were watered, the tankage being fed as a thin slop. The plats used by lots 3 and 4 opened into an alfalfa pasture. The hog house was placed in the alfalfa field, so that the hogs would have to pass through the alfalfa in going to and from the cornfield. All weeds and volunteer alfalfa were removed from the plats where the hogs got corn alone or corn and tankage.

The results secured with the duplicate lots each year were relatively uniform. In no case were the gains cheaper or the quantity of corn required for 100 pounds of gain less in the corn lot than in the tankage lot, and in only one tankage lot were they cheaper than any pasture lot. One tankage lot in 1915, however, made slower gains than either of the pasture lots and slower than one of the corn lots; and one corn lot made faster gains than one of the pasture lots. With this exception, the results of the duplicate lots were relatively the same. In 1915 the hogs required more corn per 100 pounds of gain than was required in 1914. This was probably due to the poorer quality of the corn in 1915. The corn that was added to the plats in 1915 had also been badly damaged by hail. As the results from the 1914 experiment were almost identical with those of the 1915 experiment, only the 2-year average will be discussed here.

*Corn alone.*—The corn hogged by the four lots receiving no supplementary feed was estimated as the equivalent of 1,091 pounds of shelled corn, and the equivalent of 209 pounds of shelled corn was added, making a total of 1,300 pounds of corn consumed. These lots made an average gain of 248 pounds. For each 100 pounds of gain they consumed 524 pounds of corn, valued at $5.61.

*Corn plus alfalfa pasture.*—At the time of year when corn is hogged alfalfa makes slow growth. Before the experiment closed, the alfalfa was furnishing but little feed. The hogs receiving alfalfa as a supplementary ration had access to about the same area of alfalfa pasture as was occupied by the corn plat. They were charged at the rate of $1 an acre for the use of the alfalfa pasture after the last cutting. The lots made a total gain of 310 pounds. It was estimated that they hogged 1,163 pounds, and 220 pounds were added to the plat, making an equivalent of 1,383 pounds of shelled corn consumed. It required 446 pounds of corn, supplemented by alfalfa pasture, to make 100 pounds of gain, which cost $4.88.

*Corn and tankage.*—The lot on corn and tankage made 343 pounds of gain. It was estimated that the corn plat yielded 1,038 pounds, and 349 pounds of corn were added, making a total of 1,387 pounds consumed. In addition to the corn, the lot was fed 100 pounds of tankage. The tankage cost $3.20 per hundredweight, delivered at Mitchell, Nebr., in 500-pound lots. For each 100 pounds of gain made, the hogs ate 405 pounds of corn and 29 pounds of tankage. The gains cost $5.26 per 100 pounds.

A summary of the two years' results of these experiments, calculated to an acre basis, is given in Table IX.

TABLE IX.—*Results of hogging corn, with supplementary feed, at the Scottsbluff Experiment Farm in 1914 and 1915.*

| Items of comparison. | Corn only. | Corn and alfalfa pasture. | Corn and tankage. |
|---|---|---|---|
| Number of lots | 4 | 4 | 4 |
| Number of hogs per acre in each test | 9 | 9 | 9 |
| Number of days | 66 | 66 | 66 |
| Average initial weight per hog ... pounds | 81.7 | 81.7 | 81.0 |
| Average final weight per hog ... do | 164.4 | 185.0 | 195.3 |
| Average daily gain per hog ... do | 1.25 | 1.57 | 1.73 |
| Total gain per acre ... do | 744 | 930 | 1,029 |
| Corn consumed (estimated yield plus corn added) ... do | 3,900 | 4,149 | 4,161 |
| Financial statement: | | | |
| Value of gains (at 7 cents per pound) | $52.08 | $65.10 | $72.03 |
| Cost of tankage (300 pounds, at $3.20) | ........ | ........ | 9.60 |
| Charged for alfalfa pasture | ........ | 1.00 | ........ |
| Net returns per 100 pounds of corn | 1.34 | 1.55 | 1.50 |
| Cost per 100 pounds of gain (corn $1.07) | 5.61 | 4.88 | 5.26 |

The data given in Table IX are the averages of four lots in each case and are calculated to an acre basis. The hogs were on the experiment 77 days in 1914 and 55 days in 1915, or an average for the two seasons of 66 days. The average initial weight of the shotes in the different lots was 81 pounds, and the average final weight was 164.4 pounds for the corn-alone lot, 185 pounds for the pasture lot, and 195.3 pounds for the tankage lot, or 1.25, 1.57, and 1.73 pounds of daily gains, respectively. The tankage lot made 38 per cent faster gains than the corn-alone lot and 10 per cent faster than the pasture lot. The total gain, on an acre basis, was 744 pounds where the hogs received only corn, 930 pounds where they had access to alfalfa pasture, and 1,029 pounds when fed 300 pounds of tankage in connection with the corn. The net return per 100 pounds of corn consumed was $1.34 where corn was fed alone, $1.55 where the hogs had access to alfalfa pasture, and $1.50 when they were fed tankage. A 100-pound gain cost $5.61 in the corn lot, $4.88 in the pasture lot, and $5.26 in the tankage lot.

From the results of these tests it appears that it would be better to buy tankage at $3.20 per hundredweight and feed it to hogs in connection with hogged-off corn than not to supplement the corn, but when the hogs can have access to alfalfa pasture it is doubtful whether it would pay to feed tankage.

The chief advantage of hogging corn is that the farmer is spared the expense of harvesting the crop, hauling the manure back to the land, and feeding the corn to the hogs. A disadvantage is the cost of fencing. It seems certain that hogs will make as many pounds of gain from a bushel of corn in the field as they will if the corn is harvested and fed in a dry lot. The question for the farmer to decide, then, is whether it is cheaper to harvest the crop and feed the hogs in a dry lot or to fence the corn and let the hogs themselves harvest it.

## SUMMARY.

Because of the relatively small capital and short time required to get a start in the swine industry and because of the high efficiency of hogs in utilizing certain field crops, swine production is a specially promising industry for irrigation farmers. In order to secure information regarding methods of utilizing hogs in the disposal of certain field crops produced on irrigated lands, experiments were conducted at the Scottsbluff Experiment Farm on the North Platte Reclamation Project in 1912, 1913, 1914, and 1915.

In three years' experiments, including eight lots of hogs, in which alfalfa pasture was supplemented with a 2 per cent ration of corn, an average gain of 3,181 pounds per season was made from an acre of alfalfa pasture and 7,844 pounds of corn. It required an average of 2.47 pounds of corn in addition to alfalfa pasture to produce 1 pound of pork. If the gains are valued at 7 cents a pound and corn at 60 cents a bushel, or $1.07 a hundredweight, the average annual return was $138.75 per acre of alfalfa pasture. If the corn fed is valued at 60 cents a bushel and the alfalfa pasture at $15 an acre the average cost of 100 pounds of gain was $3.11. If the average yield of the alfalfa plats in the same field is assumed to represent the yield of the pastured plats the hogs paid an equivalent of $25.13 per ton of hay.

In two years' experiments with alfalfa pasture, with and without supplemental feed, an average annual return of $45.08 per acre was secured where no supplement was used, as compared with $70.20 where a 1 per cent ration of corn was used—$128.49 from a 2 per cent ration of corn—$121.96 from a 2 per cent ration of barley, and $168.25 from a 3 per cent ration of corn. The rate of gain and the carrying capacity of the pasture increased with the quantity of grain fed. Ground barley appeared to be as good, pound for pound, as shelled corn as a feed for hogs on alfalfa pasture.

Sows and pigs on alfalfa pasture, with a 2 per cent ration of grain, made an average gain of 1,574 pounds per acre of alfalfa pasture from May 1 to July 1, or a net return of $66.84 per acre. When corn was used the return varied from $54.11 to $69.97 per acre, and when barley was used the return was $77.76 per acre.

In three years' experiments, hogging corn without supplementary feed produced an average of 896 pounds of gain, worth $65.72 per acre, or $1.50 per hundredweight of the estimated yield of corn.

In two years' experiments, hogging corn without supplementary feed produced an average of 744 pounds of gain, worth $52.08 per acre, as compared with 930 pounds of gain, worth $65.10, where the hogs had access to alfalfa pasture, and 1,029 pounds of gain, worth $72.03, where the hogs were fed tankage in addition to the corn. Where no supplementary feed was used the hogs paid $1.34 per hundredweight for the estimated yield of corn, as compared with $1.55 per hundredweight where the hogs had access to alfalfa pasture and $1.50 per hundredweight where tankage was used. The use of either alfalfa or tankage resulted in more rapid and cheaper gains than were secured where no supplementary feed was used.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 489
Contribution from the Bureau of Entomology.
L. O. HOWARD, Chief.

Washington, D. C. ▼ December 2, 1916

# A SURVEY OF BEEKEEPING IN NORTH CAROLINA.

By E. G. Carr, *Specialist in Beekeeping.*

IVERSITY GENERAL

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## INTRODUCTION.

A survey of the State of North Carolina recently has been made in order to determine the present conditions, possibilities, and needs of the business of beekeeping, with special reference to the best means of supplying these needs. It seemed desirable to learn why North Carolina beekeepers are receiving relatively small returns, whereas there was a reason to believe that opportunities for profitable beekeeping were on every hand. This survey began October 1 and ended December 22, 1915.

In this survey, counties of Surrey, Henderson, Clay, Haywood, Jackson, Buncombe, Madison, Mitchell, McDowell, Iredell, Randolph, Forsyth, Guilford, Alamance, Pamlico, Beaufort, Pender, Washington, Martin, and Sampson were included.

The census figures for the year 1909 show 36,248 farms reporting bees, with a total number of colonies of 189,178, thus giving the State fourth rank for number of colonies in the United States. The honey produced was valued at $211,607 and the wax at $18,979, a total valuation of $230,586, which gives the State eleventh rank in

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Note.—This bulletin treats particularly of beekeeping conditions in North Carolina, but is of interest to beekeepers generally.

The author wishes to express his appreciation to the beekeepers visited for many kindnesses, also to the county agents, who greatly facilitated the work by arranging for meetings of beekeepers. He also expresses his appreciation of the aid furnished by Prof. Franklin Sherman, jr., State entomologist, for data concerning beekeepers and for assistance in planning routes.

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value of hive products. The State ranks second in value of wax produced. The value of bees per colony is reported at $2.04. Attention is called to the fact that these figures are not complete, as many of the bees in the State are not on farms and many on farms evidently were not reported.

In brief, the survey fully verifies Prof. Franklin Sherman's[1] statement that "there is perhaps no other industry in the State of equal importance, and with equal opportunities for development, which is so disorganized, so disconnected, and suffering so badly from lack of careful attention and better methods as is the beekeeping business."

No doubt bees have been in North Carolina for a long time, but the business of beekeeping has received so little attention that, except in a comparatively few cases, absolutely no advance has been made.

## PRESENT CONDITIONS.

### TYPES OF HIVES.

Most of the colonies of bees in North Carolina are housed in hollow logs or "gums." Some are kept in upright box hives, "plank" or "tall gums," and only a small percentage are in some type of movable-frame hive, locally called "patent gums." The eastern and western parts of the State have the largest percentage of bees in logs, while through the central part the majority of the bees are in movable-frame hives. This condition appears to be due partly to the fact that the beekeepers are slow to adopt new methods, particularly as in some cases movable-frame hives have been tried with poor results, owing to lack of knowledge necessary to get good returns. Beekeeping as practiced by most of the beekeepers is not profitable, and the present returns by the old methods are not sufficient to make obvious to them the desirability of an expenditure necessary to place the bees in movable-frame hives.

Some are using homemade hives with movable frames, and, where the hives are made with sufficient accuracy to insure proper spacing of the frames, they are giving satisfactory results. White pine of fair grade suitable for hives can be had at small cost in the western part and a soft cypress (white cypress) in the eastern part of the State. A considerable number of factory-made hives have been sent into the State, made of yellow pine of poor quality and with the frame spacing so inaccurate as to make proper manipulation impossible. Best results can not be secured with such equipment.

For the most part the population of North Carolina is scattered and transportation is poor; hence there is not the free interchange of ideas which occurs in sections where the population is dense.

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[1] Sherman, Franklin, Jr., 1908. Beekeeping in North Carolina. Bulletin of N. C. Dept. of Agr., vol. 29, no 1.

Knowledge of improved methods of beekeeping has not reached the majority of those owning bees. In case reports of good profits from bees elsewhere have been received, these have been so far above the amounts that are being secured by the old methods that the reports have met with little credence. In very few instances have efforts been made to secure like results.

### RACES OF BEES.

Almost all the bees in the State are German (black) hybrids, practically none being found without some trace, however slight, of Italian blood. Numerous efforts have been made to improve the stock by introducing pure Italian queens, but, with few exceptions, this has produced bees which so vigorously resent disturbance that such attempts at improvement have been discouraged. Since the color of the bees in every case has been light yellow, it is quite likely that there has been some Cyprian blood in the stock secured. A few apiaries are stocked with Italians and an effort is being made to keep them pure—a rather difficult task, however, because of the presence of so many wild hybrid colonies.

One beekeeper had used a few colonies of Carniolan bees, but has discontinued beekeeping and no data are obtainable regarding their comparative value in North Carolina.

### SHADE.

Shade for the hives, either natural or artificial, is considered by almost all beekeepers in North Carolina to be necessary to avoid melting of the combs in the summer. It would be unnecessary, however, were it not for the fact that the entrance in the log or plank "gum" consists merely of a few V-shaped notches or a small slot, entirely inadequate for proper ventilation of the hive in hot weather, This conclusion is supported by cases in the central and eastern parts of the State, where beekeepers have provided large entrances and have raised the hive from the bottom board to allow abundant bottom ventilation and have dispensed with shade without harmful results. The western part of North Carolina is mountainous and cooler in summer, making extra ventilation less important.

### ARRANGEMENT OF HIVES.

In the western part of the State it is the custom to place the log or plank "gum" on long benches or on a flat rock, which rests on four stakes driven into the ground. In the eastern part, as rocks are not obtainable, benches only are used. If space will permit, the placing of hives in a single row close together is practiced. Perhaps 100 "gums" will be found in one row. Aside from using natural shade when convenient, no attempt is made to locate the hives near natural windbreaks or to face them to any particular point of the compass.

### SWARMING.

Uncontrolled swarming always results in a greatly reduced honey crop. A colony of bees kept together will store more surplus honey than will the same bees divided by swarming into two or more colonies, as each swarm must use a large amount of honey in order that they may construct combs for the new hive. This honey of course is lost to the beekeeper. Further, this division of the colony into two, or more, reduces the available force of field bees, since it is necessary that a certain number remain constantly in each hive properly to carry on the hive work. It is obvious then that when the bees are kept working together in one hive less are needed for inside hive work and more are available as gatherers.

With few exceptions, no effort is being made in North Carolina to prevent or to control swarming, and great numbers of swarms are annually lost to the beekeepers by flying to the woods. Further, many after-swarms issue, and this weakens the parent colony so that it not only can not produce surplus honey, but often it dies. Many of the weak after-swarms also die. In many cases the beekeeper has at the end of the season only the first swarm to show for his labor, no honey having been secured and both the old colony and the after-swarms having perished. Beekeepers boast of many colonies which cast three swarms, but with these results. It is obvious that under these conditions a good honey crop is impossible.

### WAXMOTH.

While, as is well known, the larvæ of the waxmoth can do no damage in a strong, healthy colony of bees properly cared for, this enemy is recognized by all North Carolina beekeepers under different names, such as "weevil," "fly," or "worm." No adequate estimate can be made of the loss through its depredations, but it surely amounts to a large sum. Since the climate of North Carolina is not so rigorous as that farther north, the waxmoth has opportunities to work for a correspondingly longer period of the year. There is no climatic reason, however, why the ravages of this insect should not be stopped. The loss is due chiefly to excessive swarming, or, to be more explicit, to allowing after-swarms to issue. This is further aggravated by the great amount of German (black) blood in the bees, since it is generally admitted that black bees do not repel the waxmoth as do Italians.

### DISEASE.

*American foulbrood.*—Samples of this disease were received by the Bureau of Entomology from Guilford County in 1911 and from

Madison, Mitchell, and Buncombe Counties in 1912. It was found that the sample from Buncombe County had been taken from a shipment of bees from Kentucky, in which the trouble was at once noticed and given radical treatment, and, so far as can be learned, the disease was entirely stamped out. In Guilford County the disease has been receiving careful attention. The beekeeper from whose yard the sample was sent has examined practically every colony of bees in the neighborhood and has found no disease except in his own apiary. There it has been so reduced that only two colonies showed infection in 1915 and in these it was light. The infection in Madison County is great and that in Mitchell County is considerable, and disease is spreading in both counties.

*Sacbrood or "pickled brood."*—This disease was observed in one case. Since even where some type of movable-frame hive is used examination of the brood nest is but little practiced, no definite idea of the extent of this disease can be formed.

*Paralysis.*—This condition was reported a number of times, and always by the better beekeepers. This does not indicate that it is absent where bees receive less care, but, it is believed, the less careful beekeepers fail to observe closely or else do not recognize the disease. In one yard of over 100 colonies the owner reports 50 per cent of the colonies affected by paralysis at some time during the season. The usual treatment is the sprinkling of sulphur on top of the frames and at the entrance, but with doubtful benefits.

## WINTERING.

Perhaps no one thing connected with successful beekeeping is receiving as little attention in North Carolina as is protection for the bees in winter aside from that provided by the hive.

A study of weather records for Asheville from November 1, 1914, to March 31, 1915, shows that a daily variation in temperature of 20° F. is frequent. The maximum variation was 40°, which occurred once, and the minimum 2°, which occurred five times. The maximum temperature during this period was 62° and the minimum 4°. Five times during this period the temperature fell below 20°, twenty times below 25°, and forty times below 30°, or, on an average, below 30° once in three days. The figures for Wilmington are as follows: Maximum temperature, 76°; minimum temperature, 20°. Twice the temperature was below 25° and below 30° eight times. These two points are mentioned, as they probably represent the extremes of temperature in the State.

Only two beekepers in the State, so far as known, are providing protection for the bees in winter, and in these two cases it is slight. One beekeeper places an empty super filled with leaves over the brood chamber, and the other is using a hive which takes a super of thin lumber inside an outer shell, and when the supers are removed the shell is filled with pine needles, locally called "pine straw."

There is considerable evidence of the value of the protection afforded by thick log "gums" in winter. This is to be expected. since all have walls 2 or 3 inches thick. When the subject of winter protection is mentioned, the North Carolina beekeeper states that the mildness of the climate makes extra protection unnecessary. Its value is apparent to the best beekeepers when it is shown that extra packing will keep the bees quiet during the season when no nectar can be gathered, since they all agree that bees expend too much energy needlessly during this period.

## QUEEN REARING.

There are three queen-rearing apiaries in the State, with a total output of from 1,500 to 2,000 Italian queens annually. These queen-breeders produce light-colored bees. Queen-cells are started in the queenless side of a colony, divided by queen-excluding zinc. Both small twin mating-boxes and nuclei with full-size frames are used for mating queens.

## TYPES OF HONEY.

There are five distinct types of honey produced in North Carolina, as follows: *Bulk comb-honey*, produced in shallow frames (5⅜ inches deep), is cut out and packed in 5, 10, and 15-pound tin buckets, with enough extracted honey added to fill up the spaces. Care is used to keep the queen out of the storage combs, in order that they may not be darkened by having bees reared in them. Combs containing pollen are not permitted in honey of this type. *Chunk honey* is produced in log or box "gums" and is "robbed" from the top of the hive in irregular chunks after the "head" or top of the "gum" has been removed. Frequently the comb has been darkened and toughened by having brood reared in it, and much pollen—"beebread"—finds its way into this product. No regular size or shape of package is used for this type of honey, the customer usually furnishing the container. *Comb-honey*—"section or box honey"—is produced in the commercial section, locally known as honey box or pound section. *Extracted honey* is stored in either deep or shallow frames and is removed by the honey extractor and packed in 50-gallon barrels. Honey in this form is secured unmixed with pollen or other foreign substances. *Strained* or "*squeezed*" *honey* is stored by the bees in the log or plank "gums," the honey being obtained by killing the bees with sulphur fumes, cutting the combs from the hives, and at once mashing up the combs and putting the mass in a thin cloth sack, so that the honey can drip out. Sometimes the cappings are removed from the combs, which are placed in a slanting trough, and, after some of the honey has dripped from the combs, the residue is pressed to remove the remainder of the honey. The resulting product contains considerable pollen and other foreign substances. It must not be thought that extracted and strained or squeezed honey are the same; neither are bulk comb-honey and chunk honey identical.

### SIZE OF CROPS.

The number of beekeepers of all classes whose methods have been studied is sufficient to indicate the amounts of honey in the different forms now secured by those who are really giving the bees some chance to do what they can. The average amount of comb-honey in sections is given at 40 pounds per colony. The amount secured in the eastern part of the State by extracting averages 60 pounds. The data regarding strained or squeezed honey were somewhat indefinite, being given as 2½ to 6 gallons or 30 to 72 pounds per "gum." This includes of course the entire amount of honey in the hive when the colony is killed. It is possible that the custom of killing the bees and taking the honey in the full moon in June may result in a smaller amount being secured than if the killing were left until gathering had ceased in the fall. The average production of bulk comb-honey per hive is given as 50 pounds. These figures are all conservative, being based on a series of years including good and poor seasons. Mention may be made of the production of 10 gallons of squeezed honey, 120 pounds of bulk comb-honey, or 150 sections by a single good colony in good seasons, but while these amounts have been secured in good seasons, the figures given previously are being duplicated annually.

### BEESWAX.

No effort is made to secure all the wax from old combs and only the crudest methods are used in rendering. No wax-press was seen which was capable of sufficient pressure to get most of the wax; in fact the only press used is made of two pieces of lumber hinged at one end. The free ends are brought together while the sack containing the hot material is between the sticks near the hinged end. The wax produced in all parts of the State is small in quantity, due to inefficient methods of rendering, but it is of good quality and free from foreign matter.

Although the State ranks second in the amount of wax produced, this should not be considered as a favorable condition, since it results from the practice of killing bees to get the honey. With good beekeeping the destruction of combs in this way will not be practiced, but the total output of wax will probably not be decreased if better methods of rendering are employed.

### VALUE OF HONEY AND WAX.

The prices received by the beekeeper for honey and wax in North Carolina have a wide range. In some localities and for some honeys the prices are good, as compared with prices in other parts of the United States; in other places they are entirely too low. The type of honey and care used in production are important factors in regulating the price, but in some cases no good reason for the low prices can be given, except lack of organization and distribution. Failure to learn the market value is probably the cause of the low prices obtained for beeswax in the western part of the State and for comb honey in the eastern part.

Bulk comb honey and chunk honey, which are the common types in the western and central parts of the State, have been sold in recent years by the beekeepers at 12½, 15, and 20 cents a pound, depending on the quality; 20 cents has been the common price for sourwood or other light-colored and mild-flavored honeys, such as basswood. Section comb honey in the western and central parts has brought the producer 15 to 20 cents a section, while in the eastern part only 10 cents a section is secured, although the product is good in color and finish. Extracted honey in 50-gallon barrels frequently sold for 7½ to 8 cents a pound, while strained or squeezed honey, the production of which is principally in the east, commanded the lowest price—around 40 cents wholesale and about $1 a gallon retail.

The price of beeswax also has a wide range, and, singularly enough, it is just the reverse of honey prices; the lowest, 20 cents a pound, is paid the producer in the western part of the State and 28 to 32 cents in the eastern part.

### MARKETING HIVE PRODUCTS.

No more encouraging features can be mentioned than the eagerness of the market for honey, particularly through the central and western parts of the State, and that bulk comb honey has a ready sale at good prices. The markets in these localities prefer honey in this form. While producers in the eastern part received last fall only 10 cents a section for their product, comb honey by the carload came into the central part of the State from the west, and also some from Tennessee and Georgia. With proper distribution, the eastern producer could secure at least 15 cents a section for his product, which is the price received for the honey from outside sources.

Little honey is shipped from North Carolina. From the east some comb honey goes to Norfolk and some extracted and strained honey is shipped to New York, but the consumption of honey in the State is far above the local production, and the demand is therefore not supplied.

The survey indicates that the demand for sourwood honey will continue to be much above the supply for a long time, as it has the preference locally over any other kind. When its qualities become known beyond the locality of production, the demand may be greatly increased.

### PROFITS OF BEEKEEPER.

The receipts from a colony of bees range from nothing to $20 or more per year. Such a statement only shows what such combinations as a good beekeeper and a good season on the one hand, or a poor beekeeper and a poor season on the other, will do.

Careful inquiry and investigation of the amounts of honey secured and the prices obtained by the best producers of the different types of honeys show that the receipts per colony from the production of comb honey is $5; of extracted honey, $4.50; of strained honey, $2.50; of bulk comb honey, $7.50. It is well to bear in mind that these returns are obtained only by those who are giving bees considerable attention. Hundreds of those having bees are receiving almost nothing from them, except a little honey of inferior quality for home use.

### PROPOLIS.

The propolis in the swamp district of North Carolina is gray, does not stain the section, is not abundant, and is easily removed, all of which favor comb-honey production. It is reported that this propolis is gathered from sweet gum (*Liquidambar styraciflua*), and when chewed it resembles chewing gum.

### LITERATURE.

Few of the beekeepers of North Carolina are making good use of the available bee literature; in fact, few have a book on beekeeping or read a bee journal.

In 1908 Sherman issued a stimulating bulletin[1] which was rather widely distributed among the beekeepers. This, so far as known, is the only publication dealing specifically with the problems of the North Carolina beekeeper.

### BEEKEEPERS' ASSOCIATIONS.

A few years ago there was a small society of beekeepers in the western part of the State, but no definite data on the present status of the association could be secured. Inquiry also reveals a desire among the more advanced beekeepers for a State organization of beekeepers so that meetings can be held and their peculiar problems discussed. No doubt such an organization easily could be effected. The length of North Carolina and the slowness of travel from east to west would make it desirable to have some agreement whereby the meetings could alternate between the eastern and western parts of the State.

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[1] Sherman, Franklin, jr., 1908. Beekeeping in North Carolina. Bulletin of N. C. Dept. of Agr., vol. 29, no. 1.

## ATTITUDE OF BEEKEEPERS TOWARD IMPROVED METHODS.

One of the hopeful signs, if not the most hopeful one, is the attitude of the beekeepers toward improved apparatus and methods. There is not the self-satisfied attitude which is often met elsewhere and which is so impossible to overcome. There was shown an eagerness to learn and to make use of the information in cases where certain simple manipulations have been explained.

## FOLKLORE.

Superstitions regarding bees which formerly were common, such as ringing bells or beating pans to cause a swarm to settle, "telling the bees" when their owner dies so they will not also die, and a belief that selling bees brings bad luck, were encountered, as well as some which were not so common. Some beekeepers will not count the hives for fear of ill luck. It is said by the superstitious that on Washington's birthday all the hives must be slightly moved to ward off ill luck. Bees are "robbed" by killing the bees at the time of the full moon in June, as it is believed there is then little "beebread" in the hive. These superstitions will, of course, disappear with better beekeeping.

## HONEY PLANTS.

Sherman already has listed the main honey sources, although probably gallberry should have been given more prominence for the eastern part of the State bordering on the swamps and streams.

From the standpoint of nectar-producing flora and consequent manipulations the State may be divided into three parts—western. central, and eastern—without definite boundary lines. The leading honey plants in these three sections are sourwood, clovers, and gallberry, respectively. Tulip poplar, or "poplar," is purposely omitted, for, although it is abundant and is a good nectar producer, honeys from the sources mentioned above are superior and bring a higher price than does that from tulip poplar. It is believed that the beekeeper will do well so to manipulate his colonies that they will consume the honey from this source in breeding and thus attain greater strength for gathering the more desirable later honeys.

All through the mountainous and upper Piedmont sections of the State sourwood flourishes and is still abundant enough, in spite of cutting, to be the leading surplus honey plant. Going eastward, because of the increased clearing of land for agricultural operations sourwood gradually becomes less and clovers, particularly crimson clover, become more plentiful. Still continuing eastward, the cotton belt is reached, which is perhaps the poorest honey-producing region in the State. Although cotton is reported as a honey plant, there is no definite information concerning this, and the fact that there are less bees in this part of the State than in any other is further indication that this region is the least favorable for bees. This condition, however, will probably be improved by the more extensive use of crimson clover as a cover-crop and the introduction of alsike clover. After the cotton belt is passed, the low-lying lands bordering the coast and rivers are reached, with immense areas of gallberry and black and tupelo gum, producing delicious honey in abundance.

Honeydew is often reported, but data on this are very unsatisfactory, some reporting it as appearing in February.

*Sourwood* (*Oxydendrum arboreum*).—Sourwood is a rather scraggy tree of varying height, seldom exceeding 30 feet. It blossoms profusely in July, and under favorable circumstances nectar is produced in such abundance that it can not possibly all be gathered. Nectar may be dashed out by striking a bunch of blossoms in the palm of the hand. In addition to the quantity, sourwood has paramount qualities from almost every viewpoint. The honey is light in color, dense, of delicious flavor, and slow to granulate. Coming as it does about July 1 to 21, ample opportunity is given the beekeeper to prepare his colonies for best work on it. Compared with some other honey-producing plants, the season is short, but by good management there is no difficulty in securing a paying crop in the blooming period.

*Linden* (*Tilia sp.*).—The well-known basswood or linn is not abundant in the State, but is found in sufficient abundance in the north coves of the mountains to be of value to near-by beekeepers. In locations where the Federal authorities control the cutting of timber, the danger of the entire removal of the basswood is reduced. The honey from this source is light in color, of good body, and has a flavor which is generally liked.

*Tulip poplar or poplar* (*Liriodendron tulipifera*).—Tulip poplar has a wider distribution than any other source of honey in North Carolina, and it is unfortunate that the honey is dark, so that it does not command a high price. However, the honey from this source can be utilized to increase the output of honey secured from better sources. This tree is found in all parts of the State except in the lowlands of the east. It blooms from May 10–30, varying somewhat with differences in altitude.

*Clovers* (*Trifolium* spp.).—Although a number of honey-producing clovers are found in the State, crimson clover (*Trifolium in-*

*carnatum*) is of most value as a source of nectar at present. This plant is used both as a cover crop and for forage and its use is increasing. There are two varieties used, one having crimson and the other white blossoms, the crimson blooming about 14 days before the white.

Besides crimson clover, there is being introduced a considerable amount of alsike clover (*T. hybridum*) which will increase the honey crop. There is also white sweet clover (*Melilotus alba*) in a few places, but not yet enough to be of value.

*Gallberry* (*Ilex* spp.).—Bordering on the swamps and rivers of the east are thousands of acres of gallberry which produces an abundance of nectar, the honey being light in color and of good body and flavor. It is reported that bees do not work on the blossoms of this plant before 10 o'clock in the morning. The blossoming period is given as May 10 to June 5.

*Black and tupelo gum* (*Nyssa* spp.).—Black gum is abundant from the center to the eastern part of the State and is credited with much good honey. Tupelo gum (*Nyssa aquatica*) is confined principally to the southeast and is an important honey plant.

Besides the above-mentioned sources of nectar, there are a number of plants and trees of value to the beekeeper because of the pollen or nectar which they produce. A list is here given but no claim is made for its completeness. Cotton may also become important as a honey producer, as is reported to be the case farther south. However this may be, there are sufficient pollen and nectar producing plants in the State, with the possible exception of the cotton belt, to make beekeeping profitable to the person who engages in beekeeping commercially.

### PLANTS REPORTED AS VALUABLE TO BEEKEEPERS.

Elm (*Ulmus* sp.): Pollen; February; Piedmont section and eastern part of North Carolina.

Alder (* *Alnus rugosa*): Pollen; specimen from Surry Co.; February; throughout State.

Maple (*Acer* spp.): Pollen and nectar; March; throughout State.

Wild plum (* *Prunus angustifolia*): Nectar; specimen from Surry Co., March; western part of North Carolina.

Willow (*Salix* sp.): Pollen and nectar; April; throughout State.

Deciduous fruit: Pollen and nectar; April; throughout State.

Redbud (*Cercis canadensis*): Nectar; April; Piedmont section and western part of State.

Black gum (*Nyssa sylvatica*): Nectar; April; Piedmont section and eastern part of State.

Holly (*Ilex opaca*): Nectar; April; Piedmont section and eastern part of State.

Rattan (* *Berchemia scandens*): Nectar; specimen from Pamlico Co.; May; extreme eastern part of State.

Locust (*Robinia pseudacacia*): Nectar; May; western part of State and Piedmont section.

Crimson clover (*Trifolium incarnatum*): Nectar; May; Piedmont section.

Huckleberry (*Gaylussacia* sp.) or Blueberry (*Vaccinium* sp.): Nectar; May; eastern part of State.

Tupelo gum (**Nyssa aquatica*): Nectar; Specimen from Pender County; May; extreme eastern part of State.

Wild blackberry (*Rubus* spp.): Nectar; May; west and Piedmont.

Tulip poplar, locally called poplar (*Liriodendron tulipifera*): Nectar; May 10–30; throughout, except in extreme eastern part of State.

Pasture killer, "rubber weed" (**Senecio aureus*): Nectar; specimen from Clay Co.; May; western part of State.

Highland gallberry (**Ilex glabra*): Nectar; specimen from Pamlico Co.; May 15–June 20; eastern part of State.

Swamp gallberry (**Ilex coriacea*): Nectar; specimen from Pamlico Co.; May 15–June 20; eastern part of State.

Persimmon (*Diospyros virginiana*): Nectar; June; throughout State.

White clover (*Trifolium repens*): Nectar; June–July; western part of State.

Sweet bay (**Persea pubescens*): Nectar; specimen from Pamlico Co.; June; eastern part of State.

Linden, basswood, or linn (*Tilia* sp.): Nectar; July; north coves of mountains.

Sourwood (* *Oxydendrum arboreum*): Nectar; specimen from Surry Co.; July 1–21; Piedmont region and western part of State.

Rattleweed, black cohosh (**Cimicifuga racemosa*): Nectar; specimen from Buncombe Co.; July–August; western part of State.

Hercules club (**Aralia spinosa*): Nectar; specimen from Washington Co.; June–August; eastern part of State.

Sumac (*Rhus* spp.): Nectar; **Rhus glabra* from Surry Co., *Rhus copallina* also common; July; throughout State.

Smartweed (*Polygonum* and *Persicaria* spp.): Nectar; specimen of **Persicaria pennsylvanica* from Henderson Co.; August–September; Piedmont region and western part of State.

Coralberry, Indian currant, buckbush (**Symphoricarpos orbiculatus*): Nectar; specimen from Alamance Co.; July.

White snakeroot (**Eupatorium urticaefolium*): Nectar; August; specimen from Buncombe Co.

Goldenrod (*Solidago* spp.): Nectar; **Solidago altissima* from Henderson Co.; September; throughout State.

Asters, ironweed (*Aster* spp.): Nectar; **Aster ericoides* from Surry Co.; September 20 to frost; throughout State.

Spanish needle (*Bidens* spp.): Nectar; **Bidens vulgata* from Henderson Co.; September; Piedmont region and western part of State.

Stickweed, feather-edge (**Ridan alternifolius*): Nectar; specimen from Buncombe Co.; August and September; throughout State.

## POSSIBILITIES UNDER NORTH CAROLINA CONDITIONS.

The possibilities for commercial honey production are already great and there is opportunity for them to become greater. Increase in the area of land under cultivation will perhaps decrease the amount of honey secured from some sources but, to offset this, are the activities of the county agents and farmers who plan greatly to increase the planting of clovers, both as cover crops and for forage, and this naturally would result in an increase in the quantity and also in some places the quality of the honey crop. The total sum of increased revenue to the State which would accrue from the use of better methods, apparatus, and stock is so great that quite naturally the average beekeeper does not credit it. Fortunately the returns of a few of the better beekeepers are known, so as to permit a fair estimate of the possibilities, and some cases will be cited.

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* Specimens of these plants were kindly determined by Mr. P. L. Ricker, Bureau of Plant Industry.

In the northwestern part of the State a man and his son operating about 500 colonies in three apiaries secure an average income per colony of $5.60 from bulk comb-honey. In Iredell County, from 47 colonies in 1913, a beekeeper received $663 for his crop of bulk comb-honey. Near the center of the State a beekeeper started the season of 1915 with 80 colonies, increased to 125, and secured 5,000 pounds of bulk comb-honey, for which he received more than $600. In the southeastern part of the State in 1914 a producer owning 150 colonies secured 21 fifty-gallon barrels of extracted honey, selling for nearly $900. In Alamance County 23 colonies in 1915 produced section comb-honey yielding nearly $9 per colony, and the care given was practically nothing, except to hive swarms and to put on and remove supers.

Many cases like the foregoing may be cited, but these indicate the possibilities, except that it must be borne in mind—and this is said with no thought of disparagement—that these beekeepers, without exception, are making some error in their work. They fail to use full sheets of foundation, fail to control swarming, use inferior stock, or neglect to give extra winter protection to the hive, all of which reduce the production per colony, so that the figures given above do not indicate the maximum which it is possible to obtain.

It is also possible for those in the western part of the State to secure at least the usual market price of 28 cents instead of 20 cents a pound for their beeswax, and those in the eastern part who are now receiving but 10 cents for their section comb-honey to receive at least 15 cents, the usual market price for this grade of honey.

To show the possibilities more fully, the errors of a few of the best beekeepers will be pointed out in detail. The best bulk comb-honey producer visited does not have his colonies as strong as would seem possible under the existing conditions of the nectar supply, and the resultant yield is lessened. He does not give any extra winter protection and this decreases the crop. The most successful comb-honey producer visited does not use full sheets of foundation in the brood-chamber, consequently enormous numbers of drones are uselessly reared and fed to the detriment of the working force of the colony, and the surplus honey crop is reduced. He is using only one shallow hive-body for brood-rearing, hence swarming is excessive, and it is impossible to rear in such a hive a colony of bees which will get the greatest amount of surplus honey. The crop of the extracted honey producer is reduced not less than 10 per cent because of drone comb in the brood chamber, from a failure to use full sheets of foundation or to sort combs. In neither case is winter protection given. It is impossible to estimate the loss sustained by the producer of chunk honey, since no effort is made to control swarming and the bees use up an enormous amount of energy in this profitless way. However, the bees in the log "gums," because of the thickness of the walls of the hive and the abundant stores, have better winter protection than bees in any other type of hive used in North Carolina.

The inadequate census figures for the year 1909 give the total colonies of bees on farms in North Carolina as 189,178. This, however, is far below the total number in the State. Estimating the average production of 10 pounds a colony at the conservative figure of 12½ cents a pound, the present annual income from honey is $236.472. Increasing this to the conservative estimate of 50 pounds a colony, the average production of the better beekeepers, gives an annual estimated increased production of 7,567,120 pounds, or an increase in revenue of $945,890. It is difficult to estimate the increased revenue which would accrue from proper rendering of wax and from stopping the loss occurring through the depredations of the waxmoth.

Again, using the census figures for 1909, the annual output of wax is given as two-fifths of a pound per colony. With the adoption of wax-rendering methods now used by the better beekeepers, the output of wax per colony would be doubled, making the increased revenue from this source $18,979. However, with other beekeeping methods, the production of wax may decrease, as it has elsewhere. This amount added to the estimated increase from honey makes $964,869. It is obvious, therefore, that with proper encouragement and direction the beekeeping industry of the State could in a few years be increased $1,000,000 annually.

The estimate given above is based on the number of bees now in the State according to the census figures. It is possible also to add to these numbers by more thorough stocking of the field, as tons of nectar are going to waste annually. Near the center of Alamance County, for instance, in the neighborhood of Mebane, there are about 100 colonies, and Mr. E. C. Turner, county agent for the southern half of the county, who is himself a beekeeper, reports that practically no bees are kept until the extreme southern end of the county, 20 miles away, is reached.

## NEEDS OF THE BEEKEEPING INDUSTRY IN NORTH CAROLINA.

The greatest need of North Carolina beekeepers is an insight into late and improved methods of beekeeping. The majority of beekeepers in the State have not had the opportunity, either by personal contact with efficient beekeepers or from literature, to learn profitable methods of managing bees. Education in managing bees is needed to secure the greatest amount of honey and wax in the best condition for the market, thus giving the greatest returns to the producer.

## SUMMARY.

A careful study of the situation and interviews, not only with all types of beekeepers but with those who are striving to introduce methods for greater production and better distribution in other branches of agriculture, indicate that the plan which gives most promise for meeting these needs is through personal contact of an enthusiastic, expert beekeeper.

Personal contact is necessary, since few beekeepers in the State have learned the elementary principles of beekeeping and have a foundation on which to build successfully. Therefore it is necessary, at the beginning, to meet beekeepers personally, to learn their difficulties, to discover their errors, and to suggest the proper management. There is not the confidence in beekeeping as a source of revenue which is necessary for good results; hence enthusiasm must be aroused, and this is not done sufficiently through the printed page. The manner, then, of supplying this need is through an expert beekeeper who will work largely on the lines followed by the farm demonstrators, not hesitating, however, to adopt other methods which may present themselves to further the work.

North Carolina has a large number of bees. The pollen and nectar-producing flora of the State is abundant and the honey, when properly produced, is of high grade. There is a good market in the State for honey. Many more bees profitably could be kept in the State. Beekeeping is a business which, when well managed, gives quick and excellent returns. The beekeepers of North Carolina are now in the proper attitude to accept and make the best use of information which will enable them to secure good profits from the bees. In view of these facts it is highly desirable that extension work in beekeeping be inaugurated as quickly and carried on as vigorously as circumstances will permit.

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# A PRELIMINARY REPORT ON THE OCCURRENCE OF WESTERN RED-ROT IN PINUS PONDEROSA.

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## INTRODUCTION.

In the national forests of Arizona and New Mexico a varying percentage of the trees of western yellow pine (*Pinus ponderosa*) is affected by an undescribed heart-rot, known locally as red-heart, red-rot, gray-rot, top-rot, and heart-rot. The amount of this rot present varies materially with the exposure, slope, and soil on which the yellow pine is growing, as well as with the age of the timber itself. It is the main heart-rot found in western yellow pine in Arizona and New Mexico and causes an annual loss of thousands of dollars.

This heart-rot is here called "western red-rot" in order to distinguish it from the true red-heart or red-rot, a very similar heart-rot common in many species of conifers throughout the world. True red-rot or ring scale is caused by *Trametes pini*, while western red-rot is produced by an entirely different fungus.

## DESCRIPTION OF WESTERN RED-ROT.

### CROSS-SECTIONAL VIEW.

Western red-rot may show in the end of a freshly cut log any one of the following stages: (1) An early stage, in which the heartwood is firm but shows reddish to dark-brown discolored areas. Such

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areas are often fan shaped and radiate outward from the center of the log, like spokes from the hub of a wagon wheel, or they may be isolated and occur anywhere in the heartwood. (2) A more advanced, or what might be called an intermediate stage, of the rot, in which the affected heartwood is whitish or grayish in color and is so disintegrated that small pieces can be pulled out. The rotted wood consists of soft white strands of cellulose, intermixed with less rotted wood particles. The rotten wood in this stage is often so wet and soggy that water can be squeezed out of it. The white-rot or gray-rot stage is usually in the center of the log and is often surrounded by the brownish fanlike areas seen in the first stage of the rot. (3) A third or final stage of the rot, in which much of the heartwood has been destroyed, leaving the remainder in a very brittle, rotten condition, so that it easily crumbles when handled. In this final stage of the rot all of the cellulose has been absorbed by the fungus, while the wood particles left are reddish to dark brown in color. This stage sometimes occupies only a small portion of the heartwood in the center of the log and may be surrounded by one or both of the other stages.

### LONGITUDINAL-SECTION VIEW.

In a longitudinal section, as seen in sawed lumber, the different stages of the rot gradually merge into one another. In the place where the fungus entered the tree will be found the oldest stage which the rot has reached in that particular lesion. If the entire lesion originated from only one center of infection (one dead branch) and the rot has been in the tree for many years, then the three stages described will probably be represented in the one lesion, which may be anywhere from 12 to 20 feet long. There will usually be some 6 to 10 feet in the center of the log which belong to the second and third stages of the rot, while the extremities of the rot lesion will consist of the first stage of the rot.

## DEVELOPMENT OF WESTERN RED-ROT IN THE TREE.

This rot advances nearly as rapidly radially as it does longitudinally in the heartwood of the affected tree. Its radial development in the wood is rather peculiar. From the central cylinder of the rot, at irregular intervals along its entire length, narrow radial patches of rot extend outward toward the sapwood. These radial patches are the fanlike or spokelike discolored areas on the end of the log, described under the first stage of the rot. The centers of these radial patches usually consist of whitish delignified tissue, bordered by reddish to dark-brown areas of heartwood which have not yet been delignified but are in the early stages of the rot. Often some of the cellulose in the center of these patches has been entirely absorbed, leaving small irregular cavities extending to the sapwood.

From these radial patches the rot spreads in all directions, until finally the entire heartwood is involved. In tangential sections these radial patches of rot appear as irregular elliptical reddish to brown areas with white centers. These areas are two to several times longer than broad, with their greatest diameter lying parallel with the grain of the wood. There is often a small cavity bordered by the unabsorbed remnants of the delignified tissue in the center of each rotted area. Usually two to six of these discolored areas are grouped together, giving the sawed lumber a very peculiar appearance.

## COMPARISON OF WESTERN RED-ROT AND TRUE RED-ROT.

When examining the rot in the end of a freshly cut pine log it is often difficult to determine whether it is western red-rot or true red-rot. A longitudinal view of the rot, however, usually will settle the question beyond any reasonable doubt, since the following constant characters are then in evidence: (1) True red-rot, or red-heart, caused by *Trametes pini*, has many small but sharply defined pockets, or cavities, in the heartwood, lying parallel to the grain of the wood, while western red-rot never has these typical pockets. (2) The attacked wood in true red-rot is usually very firm, even in the final stage of the rot, while western red-rot in its last stage is much disintegrated and easily crumbles when handled. (3) The mycelium of true red-rot when growing in heartwood which is more or less exposed to the air is brown, while the mycelium of the western red-rot is always white. (4) The attacked heartwood in true red-rot never becomes wet and soggy, as it often does in certain stages of western red-rot.

## CAUSE OF WESTERN RED-ROT.

The fungus which causes western red-rot never forms brown, woody, perennial fruiting bodies on the boles of living affected pine trees, as *Trametes pini* does, but forms annual fruiting bodies, which are usually developed as white encrusting layers on the under side of logs lying on the ground. This fungus is also the main agent in rotting the sapwood of the cull logs and large branches of the yellow-pine slash.[1]

The fruiting bodies, or sporophores, of this fungus, as they occur in Arizona and New Mexico, are usually resupinate, with a hymenial layer consisting of minute tubes or pores. However, fruiting bodies have been found which have distinct and well-formed pilei. The pileate form of the fungus resembles very closely *Polyporus ellisianus* (*Tyromyces ellisianus* of Murrill in North American Flora); the writer, however, does not wish to call it by this name until the investigations now under way as to its identity are completed.

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[1] Long, W. H. A new aspect of brush disposal in Arizona and New Mexico. *In* Proc. Soc. Amer. Foresters, v. 10, no. 4, p. 383–398. 1915.

Lloyd reports a specimen of the same fungus from the State of Washington, collected by J. M. Grant,[1] and refers it to *Polyporus ellisianus*. The writer (through the kindness of Mr. Lloyd) has been able to examine a portion of the collection from Washington, and it agrees in all essential characters with the fungus which causes western red-rot in Arizona and New Mexico. Concerning the host of the Washington specimen Lloyd writes, "There was no note with the specimen regarding its host, excepting that it grew on a pine of some kind."

A sporophore of what is apparently the western red-rot fungus has been examined from Idaho.

Von Schrenk[2] in 1903 published a figure of a heart-rot of living trees of *Pinus ponderosa* from the Black Hills Forest Reserve in South Dakota, which is typical of the second stage (cross-sectional view) of this rot as it occurs in yellow pine in New Mexico and Arizona. It is therefore highly probable that this fungus is widely distributed throughout the West, both as a saprophyte in slash and dead trees and as a heart-rot in living timber. The writer has examined a specimen of the same fungus collected in New Jersey on *Pinus* sp. and one of both fungus and rot from Vermont on *P. strobus*.

## ENTRANCE OF WESTERN RED-ROT INTO LIVING TREES.

The western red-rot fungus enters the living tree through dead branches in the crown. It first attacks the sapwood of the dead branch; then the heartwood. It then travels down the sapwood and heartwood of the dead branch into the heartwood of the living tree. Once established in the tree, the fungus apparently continues to grow as long as the tree is alive, spreading in all directions, until often the heartwood of the entire bole of the tree, as well as that of the large branches, is invaded and rendered worthless for lumber.

## EXTERNAL SIGNS OF WESTERN RED-ROT.

No external signs were found which would absolutely determine whether or not a given standing yellow-pine tree was defective. Trees having large dead branches intermixed with living limbs and ragged and unhealthy looking crowns were often attacked by western red-rot. Such defective trees were usually located on very thin soil on steep south or east slopes, where growth conditions were very poor. However, many trees which showed no recognizable external evidences of decay were found to have western red-rot when they were felled.

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[1] Lloyd, C. G. Mycological writings, v. 4, letter no. 60, p. 4. 1915.

[2] Schrenk, Hermann von. The "bluing" and the "red rot" of the western yellow pine, with special reference to the Black Hills forest reserve. U. S. Dept. Agr., Bur. Plant Indus. Bul. 36, p. 34, 40, pl. 14, fig. 2. 1903.

## AREAS EXAMINED FOR WESTERN RED-ROT.

Before marking an area for cutting it should be determined whether the rotation is to be short, medium, or long. Often the amount and character of the defect present in the timber will be an important factor in determining what rotation is best for the area in question, especially in stands of virgin timber.

In order to throw some light on the presence of defects, especially western red-rot, in western yellow pine and its probable influence on the rotation period, studies were conducted on certain areas in the Santa Fe National Forest where both tie trees and saw timber were being cut. The main problem which demanded immediate attention was the relative amount of rot present in the black jack on these areas compared to that in the yellow pine. The special areas examined were located in Cienega, Ocho, Amole, Gallegos, and La Junta Canyons and on adjacent mesas, all of which are situated in the Cienega ranger district. The data given here were obtained mainly from Cienega, Ocho, and Amole Canyons on areas which had been cut for hewn ties. A small area near the Cienega ranger station on which both ties and saw timber had been cut was also examined for rot. The tie trees ranged from 10 to 16 inches, d. b. h., while those over these diameters were saw timber. These areas were especially suitable for a study of this character, since an unusually large percentage of the black jack (30 to 50 per cent) and nearly all of the yellow pine (85 to 100 per cent) were being cut.

There are two forms of western yellow pine called, respectively, black jack and yellow pine. Black jack is the form which this pine assumes before it reaches the age of 125 to 150 years.[1] During this period its bark is blackish to dark brown, with narrow furrows, while the yellow-pine form has lighter colored, widely furrowed bark.

## NUMBER AND KIND OF TREES EXAMINED.

In the vicinity of the Cienega ranger station, 1,691 felled black jacks and 547 felled yellow-pine trees were examined for rot. In addition to this, all of the trees 4 inches, d. b. h., and over on a sample strip 1 chain wide and 140 chains long, located on the mesa between Ocho and Cienega Canyons, were tallied by the district marking board of the Forest Service, carefully examined, and any evidences of disease or defect noted. One hundred and twenty-four felled black jacks (10 to 16 inches, d. b. h.) and 16 felled yellow pines (12 to 16 inches, d. b. h.) had been cut for hewn ties on this sample strip.

Table I shows the number of sound and defective trees on each of the areas examined and in a general way the character of the site on which the trees were located. The amount of butt-rot (probably caused by *Polyporus schweinitzii*) present on the areas examined was so small that it was not included in the table. This explains any apparent discrepancy between the sum of the sound and defective trees and the total number of trees listed in the table.

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[1] Woolsey, T. S., jr. Western yellow pine in Arizona and New Mexico. U. S. Dept. Agr., Forest Serv. Bul. 101, 64 p., illus, 4 pl. 1911.

TABLE I.—*Data on sound and defective felled trees of black jack and yellow pine.*

| Area. | Kind of timber. | Number of trees. | Sound trees. | | Defective trees (western red-rot). | | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | Number. | Per cent. | Number. | Per cent. | |
| 1 | Black jack | 210 | 206 | 98 | 4 | 1.9 | Top of ridge; growth conditions fair, mainly black jack. |
| | Yellow pine | 20 | 18 | 90 | 2 | 10 | |
| 2 | Black jack | 294 | 293 | 99.66 | 0 | ........ | Lower portion of southeast slopes and bed of canyon; growth conditions fair. |
| | Yellow pine | 84 | 73 | 86.9 | 10 | 11.9 | |
| 3 | Black jack | 126 | 124 | 98.4 | 2 | 1.6 | South and southeast slopes; thin soil; slopes steep, rocky; growth conditions poor. |
| | Yellow pine | 132 | 87 | 65.9 | 40 | 30.3 | |
| 4 | Black jack | 206 | 193 | 93.7 | 9 | 4.3 | South and east slopes; thin soil; slopes steep; growth conditions poor. |
| | Yellow pine | 76 | 57 | 75 | 14 | 18.4 | |
| 5 | Black jack | 855 | 836 | 97.7 | 14 | 1.6 | Mesas; soil good; growth conditions good. |
| | Yellow pine | 235 | 223 | 94.9 | 8 | 3.4 | |
| 6 | Black jack | 124 | 123 | 99.2 | 0 | ........ | 14-acre sample strip across mesa; growth conditions fair. |
| | Yellow pine | 16 | 13 | 81.25 | 3 | 18.75 | |
| 1–6 | Black jack | 1,815 | 1,775 | 97.8 | 29 | 1.59 | Total for all areas. |
| | Yellow pine | 563 | 471 | 83.6 | 77 | 13.6 | |
| | Both kinds | 2,378 | 2,246 | 94.4 | 106 | 4.5 | |

## DISCUSSION OF THE DATA PRESENTED IN TABLE I.

A study of Table I shows several interesting facts: (1) There is a marked difference in the percentage of black jack and of yellow pine affected by western red-rot. (2) The site seems to have a decided influence on the occurrence of this rot, especially in the yellow pine. (3) The variation in the percentage of western red-rot on the different areas shown in the table is due to several factors, the three most prominent ones being the relative proportion of black jack and yellow pine which had been cut on each area, the influence of the site on the growth of the trees, and the age of the timber. For instance, on area No. 3 the percentage of this rot in yellow pine is high, due apparently to unfavorable growth conditions and the age of the timber cut.

Table I should give a fairly accurate idea of the occurrence of western red-rot in black jack of merchantable size in this region, since 1,855 trees of this kind were examined over areas where 30 to 50 per cent of the black jack 11 inches, d. b. h., and over had been cut. As an indication of the amount of this rot present in the yellow pine, Table I is not so conclusive, since, with the exception of areas 3 and 4, all of the yellow pine shown in the table was of small diameter (12 to 18 inches, d. b. h.) and was cut for hewn ties only. This means that the percentage of trees showing western red-rot in the yellow pine on these areas will be greater than is shown in the table, except areas 3 and 4. The older the trees are, the greater the amount of rot present, since such trees have had more opportunities for infection than younger trees. However, taking the area as a whole, probably 20 per cent of the yellow-pine trees (exclusive of black jacks) will show western red-rot in some portion of the bole. The areas shown in this table are mainly covered with black jacks intermixed with only a small number of yellow pines. For instance, in the sample strip, 1 chain wide and 140 chains long, 195 black jacks were marked for cutting and 1,270 left, a total of 1,465 black jacks 4 inches, d. b. h., and over, while 108 yellow pines were marked and 22 left. Of the 1,465 black jacks present on this area, there were 605 trees of merchantable size (10 inches, d. b. h., and over) to only 130 yellow pines. This means that on such areas the percentage of western red-rot in the merchantable timber will be small compared to similar areas where the proportion of yellow pine is greater than that of black jack.

## WESTERN RED-ROT IN BLACK JACK AND YELLOW PINE.

The percentage of western red-rot in black jack for all the areas is very small, since only 29 trees out of 1,815 (1.59 per cent) showed this rot, while in yellow pine it was much greater, 77 trees out of 563 (13.6 per cent) being infected. Even then, this percentage is not high when compared with some other areas in Arizona and New Mexico. For instance, on certain sale areas on the Upper Pecos River, 70 to 95 per cent of the yellow-pine trees were attacked by western red-rot. Since this rot enters mainly through dead branches it is easily seen why fewer black jacks are attacked by it than yellow pines. The total percentage of trees attacked by western red-rot, both black jack and yellow pine, is only 4.5 per cent for all the areas shown in Table I.

Of the black jacks infected with western red-rot, nearly all were suppressed or grown under very unfavorable conditions. This indicates that all such trees should be marked for cutting when possible, not only on account of their susceptibility to this rot, but also because they will never make strong, thrifty trees. When the soil is deep and capable of producing vigorous growth in the trees, western red-rot is present only in a small degree unless the trees are very old and overmature. Such soil conditions are found on many of the mesas and near the bottoms of small canyons. There is always a marked increase in the amount of western red-rot in yellow pine growing on very steep slopes and on poor, thin soil.

## WESTERN RED-ROT AND THE ROTATION FOR WESTERN YELLOW PINE.

As to the relative efficiency of a long rotation and of a medium or short rotation period in finally eliminating this rot from the forest, the answer is very evident, judging from the viewpoint of the rot alone. Table I clearly shows that during the black-jack period the trees are practically free from this rot, but as they grow older the increasing number of dead branches makes them more open to the attacks of this fungus; that is, after the trees enter the yellow-pine stage of their growth they are more and more subject to infection by heart-rotting fungi.

In the Cienega ranger district western yellow-pine trees up to 125 or 150 years old (the black-jack period) are rarely attacked by western red-rot, for the reasons previously given, while trees over 200 years old show a much higher percentage of rot than the younger trees (black jack). Any system of cutting that will take out most of the older trees (yellow pine) and many of the larger black jacks, as well as all suppressed trees, will do much to rid the future forest of this serious heart-rot. It also follows that a short rotation will be better for the future health of the forest so far as heart-rots are concerned. It is a fundamental fact that the older a tree is, the more liable it is to be attacked by heart-rotting fungi.

## SUMMARY.

(1) A varying percentage of western yellow pines in Arizona and New Mexico is affected by a serious heart-rot called in this bulletin western red-rot.

(2) Western red-rot has three stages in its development: (*a*) An initial stage, in which the affected heartwood is firm but shows reddish to dark-brown discolored areas; (*b*) an intermediate stage, in which the diseased heartwood is whitish or gray in color and more or less delignified; (*c*) a final stage, in which much of the heartwood has disappeared, owing to the absorption of the delignified portions, while the wood particles left are brittle and crumble easily when handled.

(3) Western red-rot attacks both the sapwood and the heartwood of dead branches on living trees. It then travels down the dead branches into the heartwood of the living tree.

(4) No constant external signs were found which would absolutely determine whether or not a given living yellow-pine tree was attacked by western red-rot. However, trees growing on very thin soil on steep south or east slopes where growth conditions are very poor have a higher percentage of this rot than yellow pines situated where the growth conditions are good.

(5) Of the 1,815 black jacks examined for western red-rot, only 29, or 1.59 per cent, had this rot, while out of 563 yellow pines examined, 77, or 13.6 per cent, were attacked by this rot.

(6) So far as heart-rots are concerned a short rotation is better for the future health of the forest than a long one.

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UNITED STATES DEPARTMENT OF AGRICULTURE

## BULLETIN No. 491

Contribution from Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. PROFESSIONAL PAPER June 30, 1917

# THE MELON FLY IN HAWAII

By

E. A. BACK, Entomologist, and C. E. PEMBERTON,
Scientific Assistant, Mediterranean and other
Fruit Fly Investigations

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## INTRODUCTION.

The melon fly (*Bactrocera cucurbitae* Coq.) (fig. 1) is a pest introduced into the Hawaiian Islands from the Orient, about 1895. As shown by the reports of the quarantine officers of the Federal Horticultural Board, it is being continually intercepted at the port of San Francisco in cargoes arriving from Honolulu, and there is danger that it will be introduced into continental United States. Together with the Mediterranean fruit fly (*Ceratitis capitata* Wied.), also recently introduced, it has had a most ruinous effect upon horticultural pursuits of Hawaii. The equable climate and abundant food supply have given this pest an excellent opportunity to increase unmolested and, at the time the writers undertook the investigation herein reported, the melon fly had made impossible a free cultivation of the most valuable, economically, of the Cucurbitaceae and other truck crops. No natural agencies have thus far been discovered which serve as a practical check upon its ravages, and artificial methods of control, especially control by poisoned-bait sprays, have been found inadequate, owing to the lack of concerted and intelligent action among the oriental market gardeners. The purpose of this bulletin is, therefore, to call attention to the unprecedented ravages of this pest in the Hawaiian Islands and the danger of introducing it into the mainland United States, and to record new facts concerning its biology, rather than to offer a satisfactory method of control.

## ORIGIN.

The true Dacinae, the subfamily of the Trypetidae, to which the melon fly belongs, are almost without exception tropical or subtropical in distribution. Most of the well-defined genera have been found by Bezzi to show a restricted area of habitation and to be almost exclusively confined to the Old World. Indeed, the few species which are recorded from widely separated countries have reached their present distribution not by natural spread but by the assistance of man. The melon fly is a good example of a pest known to have been artificially introduced to new countries. Bezzi, who has given the most complete and recent review of fruit flies, stated in 1913 that the original home of the melon fly is India. Other entomologists who have traveled in the Orient for the purpose of making fruit-fly studies, particularly Compere, Froggatt, and Muir, agree with Bezzi as to its Indian origin. Perkins stated that its true home is either Japan or China, but this statement was made in 1902, before the discovery of the melon fly in India and before the studies of Bezzi were undertaken.

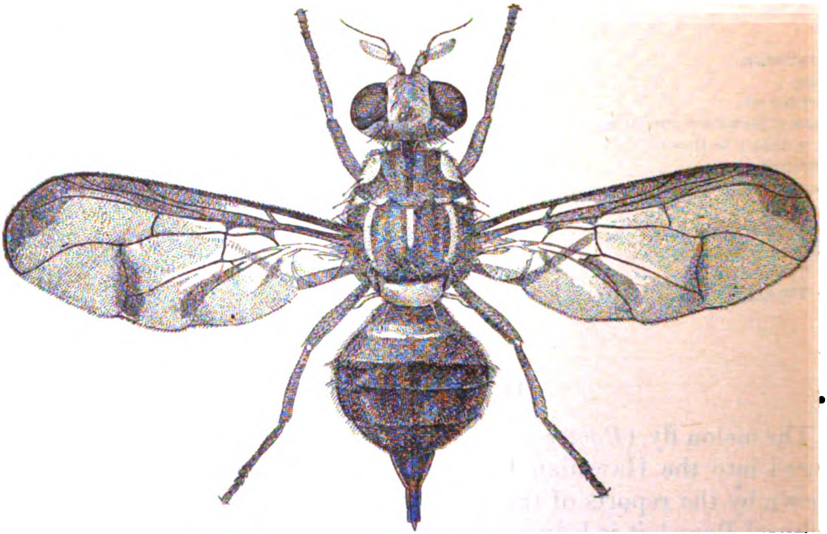

FIG. 1.—The melon fly (*Bactrocera cucurbitae*): Adult female. Greatly enlarged. (Original.)

## DISTRIBUTION.

The melon fly has been recorded from India, Ceylon, Java, Timor, Australia, the Philippines, Singapore, southern China, Japan, and the Hawaiian Islands. The references known to the writers of its presence in these countries are as follows:

*India.*—Compere first recorded the melon fly from India, where he collected specimens in and about Poona on September 28, 1903, and at Bangalore in 1916. Froggatt (26)[1] in 1909 states that, in the company of F. M. Howlett, he noted the pest in the gardens at Allahabad during May, 1909. Bezzi (36) in 1913, while studying the fruit-fly material in the Indian Museum, found pinned material collected at the following places in India: Many specimens from Calcutta, taken in April, May, June, and September; others from Durjhana, Nepal, the Terai, Ranchi, Jhansi, northwestern India, 850 feet (Brunetti); Katihar, Purneah District, northern Bengal, in October; Allahabad, United Provinces, in August; Nepalganj, Nepal Frontier, January 22, 1911; Siripur; Saran, northern Bengal, September 26, 1910; Adra, Manbhum District, October 12, 1909; and in Bombay, in gourds, October 12, 1903. Maxwell-Lefroy (18) in 1907 states that this is a sporadic and occasionally a serious pest and gives as its distribution Nasik, Pusa, Surat, Umballa, and "probably throughout India."

*Ceylon.*—The melon fly appears to be generally distributed throughout Ceylon. Green (34), in 1912, and Rutherford (40), in 1914, list it among insects of economic importance. Bezzi (36), in 1913, records specimens in the collection of the Indian Museum caught January 10 at Peradeniya. Froggatt (26) found the pest at Jaffna in 1908. Compere (33), in 1905, records specimens taken at Colombo.

*Java.*—The melon fly was reported by Dammerman (41) in 1914 from Java, where it is frequently a serious pest.

*Timor.*—Compere is our authority for the presence of the melon fly on this island.

*Australia.*—Hill (50), in 1915, has given the only record of the presence of the melon fly in Australia. He records it from the Northern Territory as a pest of melons, pumpkins, and marrows.

*Philippine Islands.*—Essig (35), in 1913, gives C. F. Baker as authority for the presence of the melon fly in the Philippines. Mr. F. Muir has recently informed the writers of its presence in these islands, and specimens have been received from Mr. McKay, of the Philippine Department of Agriculture. The melon fly was first noted about Manila by Compere.

*Southern China.*—Compere (33) states that about Macao and Canton, in 1909, he found the melon fly a serious pest but not doing as much damage as in the Hawaiian Islands. He has also found it at Hongkong.

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[1] The figures in parentheses refer to Bibliography, p. 57.

*Singapore.*—The melon fly was reported from Singapore by Compere.

*Japan.*—In 1905 Craw (13) stated that the melon fly was introduced to Hawaii from Japan. Compere reared adults from material collected in melons and cucumbers at Nagasaki according to data on file at the office of the chief quarantine officer of the port of San Francisco. Muir (38), in 1914, records the melon fly as injurious to cucurbits on the Island of Formosa.

*Hawaiian Islands.*—The first critical study of the melon fly was made from material collected by Compere (2) in 1898 at Honolulu. At the present time the pest is known to occur on all the important islands of the group.

## SOURCE OF HAWAIIAN INFESTATION.

The melon fly was without doubt introduced into the Hawaiian Islands from Japan. The interceptions of this pest from Honolulu during the past few years at the port of San Francisco make it easy to understand its introduction at Honolulu from Japan, where the pest is known to occur in vegetables grown about Nagasaki, a port in direct communication with Honolulu and from which many Japanese immigrants arrived in the islands during past years. Alexander Craw, entomologist of the Hawaiian Board of Agriculture and Forestry, wrote (13) in 1905 that the melon fly had been unfortunately introduced at Honolulu a few years previously from Japan.

That the melon fly was actually introduced is well known to all the older inhabitants of the islands interested in agricultural pursuits. Excellent watermelons and cantaloupes were abundant and cheap in the Honolulu markets, and pumpkins in large quantities were used as food for stock by certain ranchmen. At the present time these fruits are imported from California or grown in restricted areas in the islands with great difficulty. The perfect condition of the calabashes made from gourds by the native Hawaiians is additional proof that the melon fly is an introduced pest. Utensils made of gourds at the present time bear deformities and surface defects peculiar to melon-fly attack.

## EARLY HISTORY IN HAWAII.

The first authentic account of the presence and ravages of the melon fly in the Hawaiian Islands was given by Mr. Byron O. Clarke, commissioner of the Hawaiian Bureau of Agriculture during 1898. In October, 1897, soon after his arrival in Honolulu, Mr. Clarke attempted to grow cucurbits in the Kalihi district, but found[1] that a fly deposited eggs in the young shoots and that the developing larvæ killed the vines before they were a foot long. During December of the same year Mr. Clarke attempted the cultivation of summer squash, muskmelons, and tomatoes at a point about a mile north of the railroad station at Pearl City. That the pest which caused the destruction of these crops was what has since been called the melon fly was proved by the adults reared by Mr. Clarke during February, 1898. Mr. Clarke states that in 1897 the old gardens about Pearl City were thoroughly infested with the melon fly.

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[1] Correspondence, Bureau of Entomology, U. S. Dept. Agr., dated Jan. 16, 1916.

Correspondence (1) in the files of the present Hawaiian Board of Agriculture and Forestry prove that the melon fly was well established and doing damage on the island of Hawaii, about 192 miles by sea from Honolulu, as early as August, 1898, and that it was known to Prof. Koebele, at that time entomologist of the Hawaiian Bureau of Agriculture. Mr. George Compere, who visited Honolulu during November, 1898, found the melon fly doing great damage to the truck crops grown by the Orientals in the Moiliili and Waikiki districts of Honolulu and collected the first material that found its way into collections for scientific study.

To Messrs. Compere and Clarke we are indebted for all existing information regarding the melon fly in the Hawaiian Islands prior to 1900. As Clarke has shown that serious injury was being done cucurbits as early as 1897 at Honolulu and at Laupahoehoe on the island of Hawaii in 1898, it is apparent that the introduction of the pest into the islands occurred at least several years earlier and that the pest was probably established on the other two important islands, Maui and Kauai, both of which are nearer Honolulu than Hawaii. The rapidity with which the Mediterranean fruit fly (*Ceratitis capitata* Wied.) has been known to spread since its introduction at Honolulu in very recent years leaves little doubt that the melon fly existed in the islands a comparatively short time before its ravages attracted the attention of agricultural officials. Perkins wrote (8) in 1902 that the melon fly was introduced "five or six years ago." It is safe to assume that the melon fly was present about Honolulu as early as 1895.

## LITERATURE.

The melon fly was first described as a species new to science by Mr. D. W. Coquillett (2) in 1899 from specimens reared by Compere in Honolulu and forwarded to Dr. L. O. Howard, entomologist of the U. S. Department of Agriculture. Mr. Coquillett's article entitled "A new trypetid from Hawaii," published in Entomological News, contained the first information regarding the melon fly appearing in scientific literature. The first printed account (1) of its ravages, however, appeared in "The Hawaiian," a newspaper published in Honolulu during 1898, and this is given in full in the bibliography. An article entitled "A dipterous enemy of cucurbits in the Hawaiian Islands," prepared by Dr. Howard (3) and published in 1900, is of importance, as it contains the first printed statements of melon-fly ravages to be found in scientific literature. Dr. Howard gives the substance of a letter written him under date of February 14, 1899, by Mr. Compere in Honolulu.

The bibliography (p. 57) contains all references to the melon fly known to the writers. Most of it is unimportant and is conspicuously meager, as shown by the attached summaries or verbatim quotations. Prof. M. Bezzi, in the Bolletino del Laboratorio di Zoologia, 1909 (24), and in the Memoirs of the Indian Museum, 1913 (36), has treated the systematic relationship of the melon fly. Banks (30), in 1912, gave the first technical and trustworthy description of the well-grown larva. All these references, with the exception of Coquillett's article already mentioned, deal with the economic status of the pest. For the most part they merely list the fly from certain localities and contain brief references to its capacity for damage to crops, or to the desirability of establishing or making more vigilant quarantine regulations. Thus Maxwell-Lefroy (18), Howlett (20), and Fletcher (43) give information regarding the pest in India; Green (34) and Rutherford (40) in Ceylon; Dammerman (41) in Java; Essig (35) in the Philippines; Muir (38) in Formosa; Hill (50) in Northern Australia, and Compere (33) and Froggatt (26) throughout the Orient in general.

The remaining references are from Hawaiian and California sources and are the result of the presence of the melon fly in Hawaii. From the quarantine standpoint the references of Craw (7) and Maskew (42) throw light on the present-day possibilities of spread. From a biological standpoint the references of Van Dine (19), Severin, Severin and Hartung (45), and Back and Pemberton (46) are the most important.

The article by Van Dine (19) contains a concise general account of the known facts concerning the melon fly published up to 1908, in addition to a complete bibliography and the first illustrations of adult, larva, eggs, and puparium. He states that the fly requires three weeks to pass through the egg, larval, and pupal stages. Severin (45), in September, 1914, published results and observations on the melon fly which may properly be called the first careful work done on the biology, extent of injury, and methods of control. This is the most important biologic paper published up to that time and contains so many new data that it should be possessed by investigators of the melon fly. The article by the writers (46) appearing in December, 1914, gives the results of careful life-history studies and contains data on the various stages, accompanied for the first time by temperature records. The data contained in this last paper have been incorporated in the present bulletin.

While Van Dine has given us the first illustrations of the melon fly, others have been published. Howlett (20), in 1909, published a plate in Maxwell-Lefroy's "Indian Insect Life" containing an especially good figure of the adult female, besides figures of the egg, larva, puparia, and the anterior and posterior spiracles of the puparium. This plate was slightly enlarged and republished as a colored plate by Fletcher (43) in 1914, in "Some South Indian Insects." Perkins (29), in 1911, published a drawing by W. R. Potter of the adult female which was later used by Severin (45). Compere (33), Dammerman (41), and Bezzi (36) have published photographs of wings of the melon fly. Severin (45) included in his paper the first and only illustrations ever published of the damage to host plants caused by the melon-fly larvæ. These photographs were greatly reduced and much of their detail was lost. The only drawings showing larval details were published by Banks (30) in 1912, and included enlargements of the anterior spiracles, the stigmal plate, and a lateral view of the head.

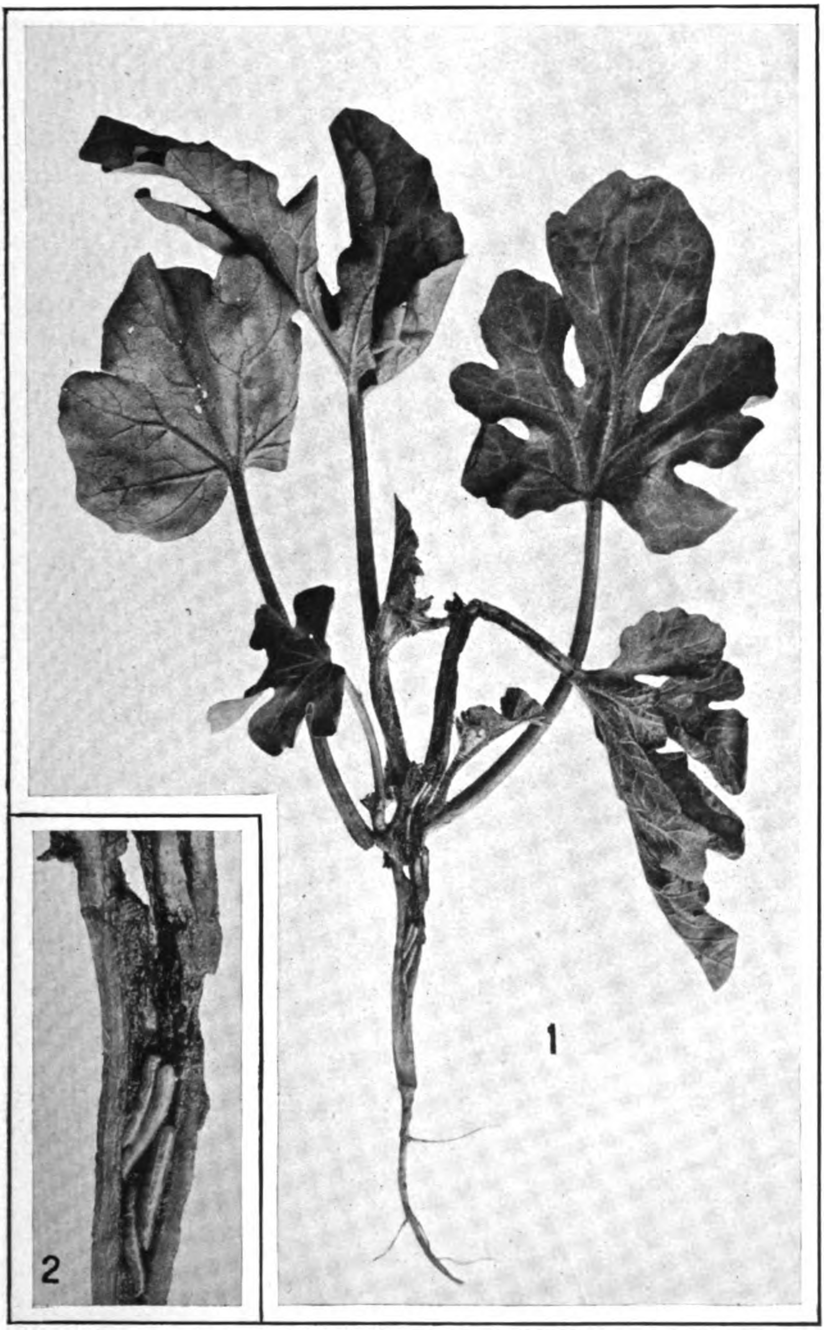
## ECONOMIC IMPORTANCE.

The melon fly is the most important pest of varieties of cucurbitaceous crops grown in the Hawaiian Islands. Its persistent attack has caused many to abandon the growing of its more susceptible host fruits, while others can be grown for the most part only under cover and at increased cost. The Mediterranean fruit fly (*Ceratitis capitata*) and the melon fly have ruined the free cultivation of fruits and vegetables in the Hawaiian Islands. Of the two pests, many consider the melon fly of the greater economic importance, as it attacks with greatest persistency those crops, such as squashes, pumpkins, and the vegetable marrows, which could otherwise be depended upon to furnish an abundant food supply for the poorer classes, and by its presence has ruined any trade with the coast in such vegetables as eggplant, peppers, etc. In 1902 Mr. Jared G. Smith, at that time director of the Hawaiian Agricultural Experiment Station, wrote (9) that the melon fly was doing great damage to cucurbits by stinging and depositing eggs in the young fruit. F. W. Terry (15), in 1906, in a preliminary account of insects of economic importance in Hawaii, wrote, "Since its arrival it has practically stopped the raising of melons, cucumbers, squashes, and tomatoes in many localities, unless these plants are carefully screened from the attack of the fly." Van Dine (11), in 1903, states that "watermelons and muskmelons are a luxury; a good melon brings 50 cents to $1 at the fruit stands in Honolulu. These products could be raised in certain sections in quantities large enough to bring them within the reach of every table were it not for the attack of the melon fly." F. G. Krauss, formerly agriculturist of the College of Hawaii, stated (14) in 1905 that were it not for the ravages of cutworms, plant-lice, and the melon fly melons would be an excellent crop for Hawaii, but that the advantage of the favorable climate of Hawaii was offset by the prevalence of these pests. Blackman (22), in 1909, places the annual loss to market gardeners as the result of melon-fly attack at three-fourths of a million dollars. Severin (45) writes that "when one stops to consider that the Hawaiian Islands are smaller than the State of Rhode Island, that the principal agricultural products are sugar, pineapples, coffee, and rice, one realizes what a tremendous amount of injury this fruit fly causes to the limited vegetable crops grown in the islands." The truth of all the foregoing statements regarding the great damage caused by this pest and its right to first rank among the pests of the market gardener has been corroborated by the writers. It is not possible to overexaggerate its importance as a serious pest under Hawaiian littoral conditions.

## INJURY.

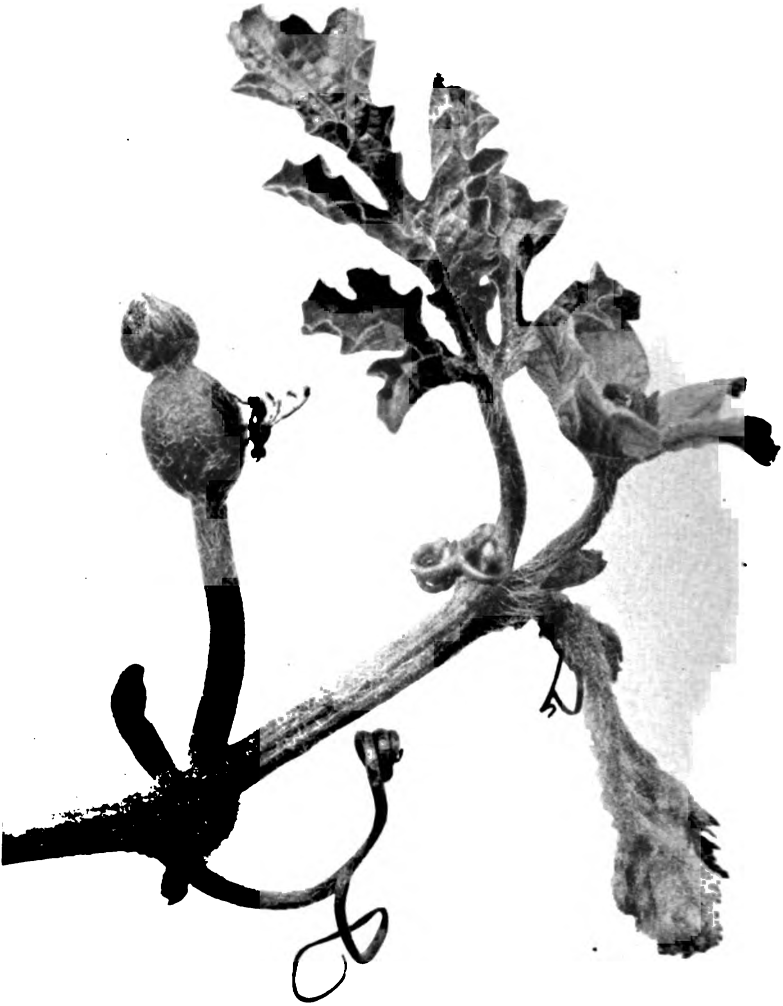
Injury due to melon-fly attack is in the nature of deformities resulting (1) from punctures made in the epidermis of the host fruit or plant when no eggs are deposited; (2) when the eggs deposited or resulting larvæ fail either to develop or to penetrate the tissues deeply; and (3) from the destruction of plant tissue by the unhindered development of the larvæ. While the fruits of the host plant are always attacked with greatest severity, no portion of the plant is immune, particularly when succulent growths are produced by hot, moist weather conditions.

*Injury to the root.*—It has been stated (45) that in many localities the seeds of some cucurbits barely germinate before the seedlings are attacked by the melon-fly larvæ, which devour the tissues of the stem, causing decay, and penetrate the roots and completely destroy the plant. This type of injury (Pl. I) is by no means the most common, but has been observed by the writers on many occasions. The writers have never known the roots of seedlings of any host other than the watermelon to be thus attacked, and then only when the plants were very succulent. Entire fields of watermelons have been destroyed by such attacks during the warmer parts of the year in a badly affected area. At other seasons and in localities more isolated from habitations, or where no host fruits have been grown for some time, seedlings are not usually affected below the ground.



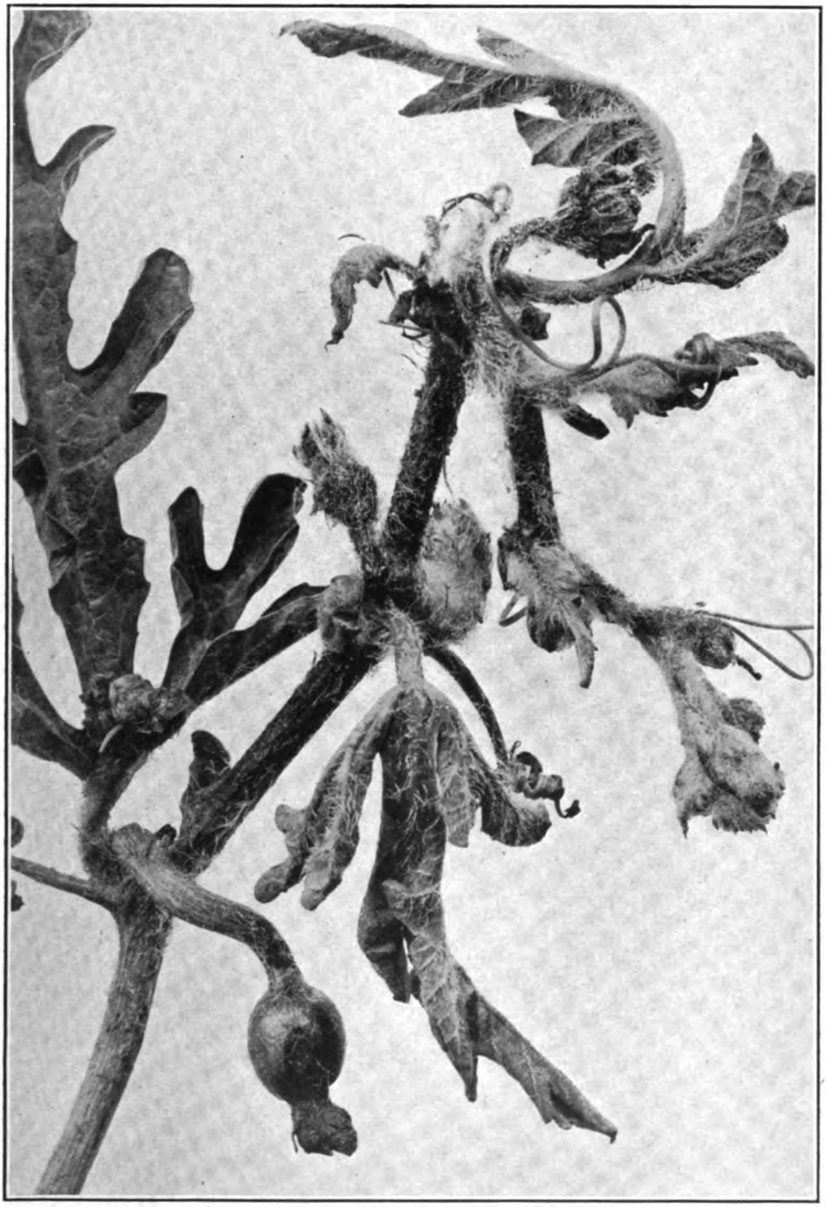
WORK OF LARVA OF THE MELON FLY (BATROCERA CUCURBITAE).

Watermelon seedling destroyed by larvæ of the melon fly feeding in the taproot, crown, and leaf petioles. Note that the leaf to the left is nearly severed from the crown, while the petiole of the drooping leaf has been completely tunneled by the larvæ. In figure 2 is shown, enlarged, the work of larvæ in the root. (Original.)



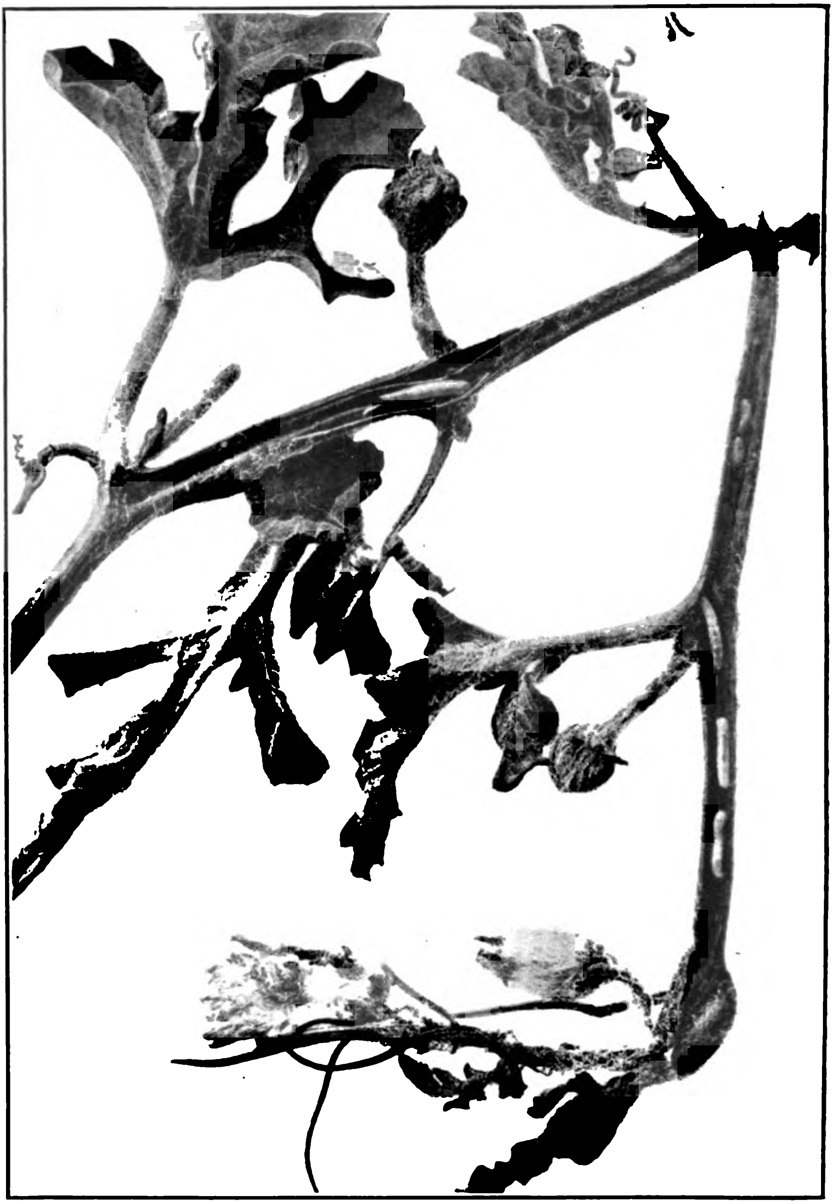
OVIPOSITION BY MELON FLY ON WATERMELON VINE.

Tip of a watermelon vine showing an adult melon fly ovipositing in the ovary of a flower still in bud, an unaffected male bloom, and the withered and drooping growing tip of the vine. A female melon fly has deposited eggs in the vine at the base of the leaf petiole, and the young larvæ hatching have nearly severed the vine at this point. (Original.)



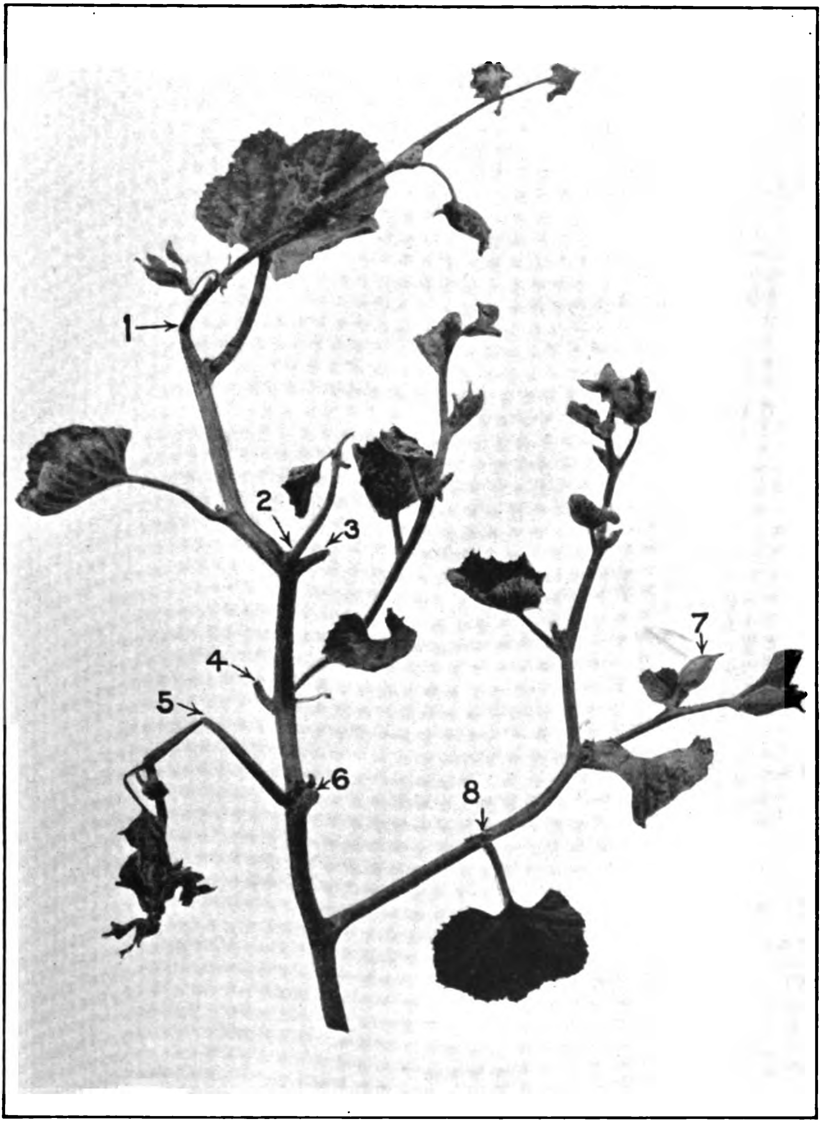
DAMAGE TO WATERMELON VINE BY LARVÆ OF MELON FLY.

Succulent watermelon vine showing the blackened and decaying condition beyond the point of attack. The eggs from which the larvæ hatched were laid at the base of the fruit stalk shown in lower portion of figure. Note that small as the young watermelon is it has already become infested, as indicated by the blackened area. For condition existing within this vine, see Plate IV. (Original.)



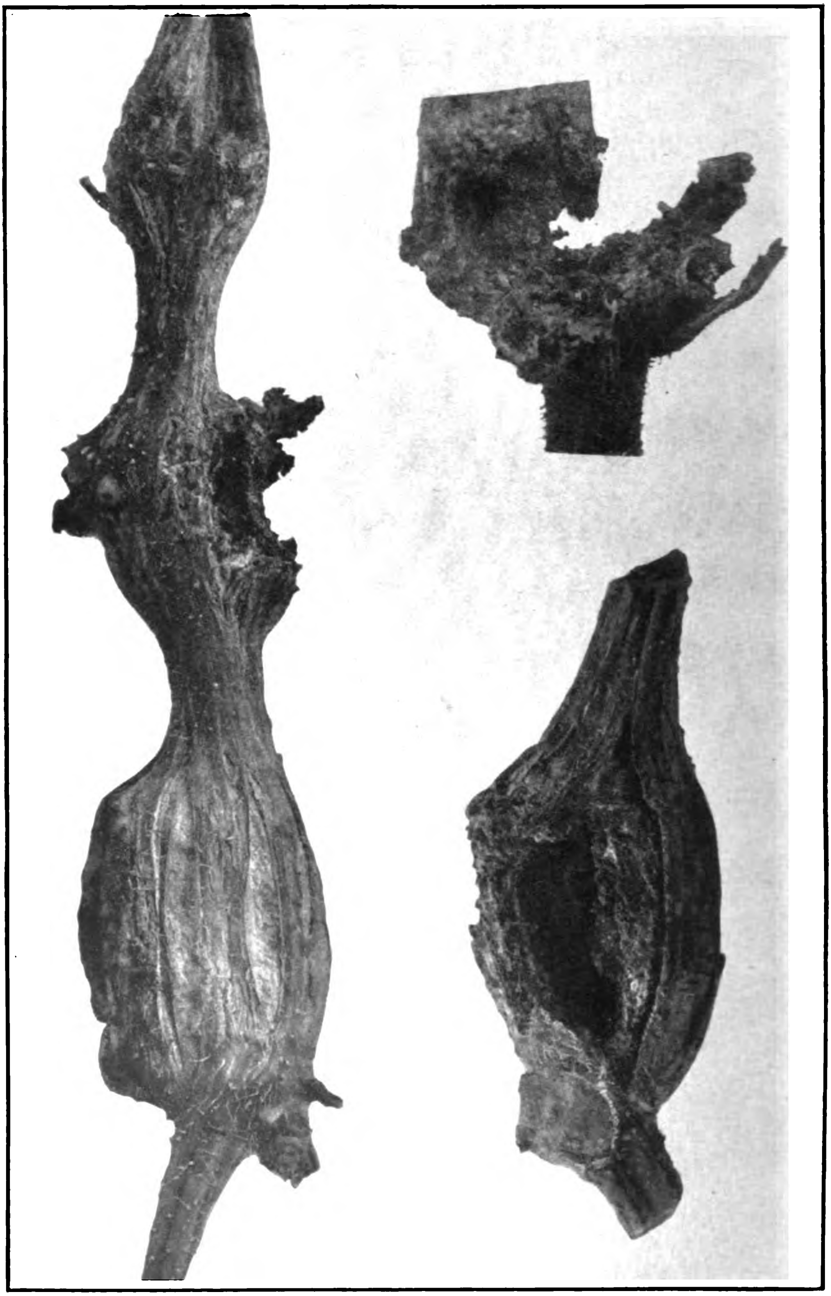
WORK OF LARVÆ OF MELON FLY IN WATERMELON VINE.

Succulent watermelon vine sectioned to expose well-grown larvæ of the melon fly which have eaten out the interior, causing the vine to wither and die back to the point of original infestation. (Original.)



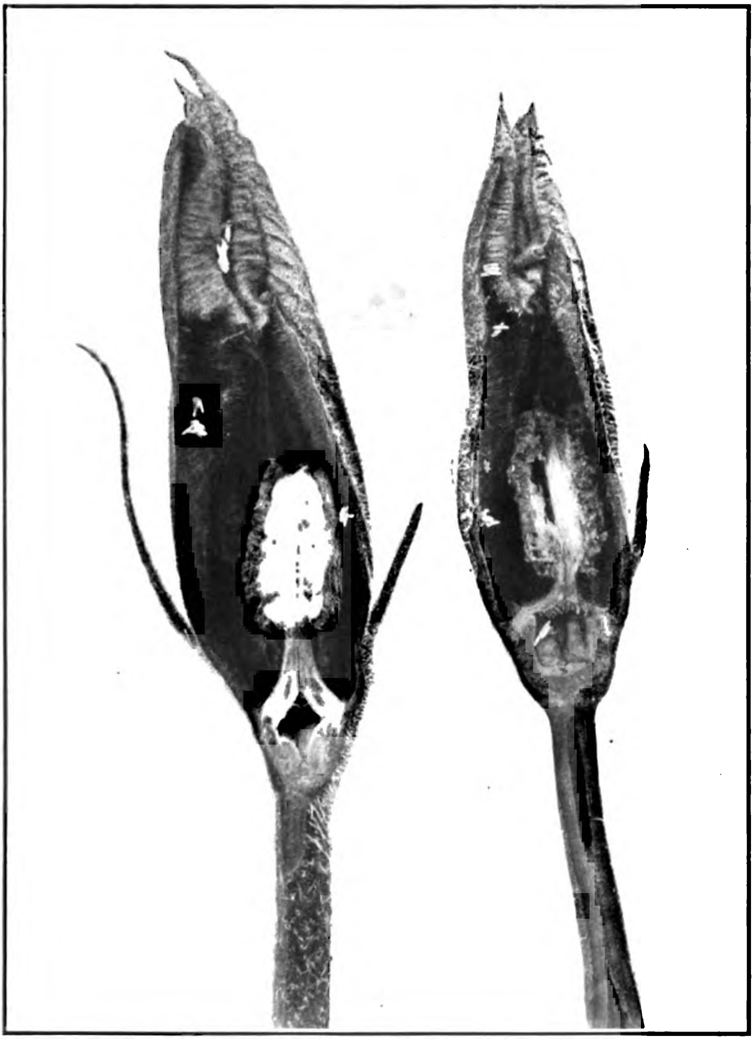
CANTALOUPE VINE ATTACKED BY MELON FLY AND DAMAGE BY LARVÆ.

Cantaloupe vines and fruits are very susceptible to attack. The vine shown has been attacked in eight places, as indicated; the larvæ developing in the stalk, petioles, or young fruit. (Original.)



SQUASH VINES ABORTED BY WORK OF LARVÆ OF MELON FLY.

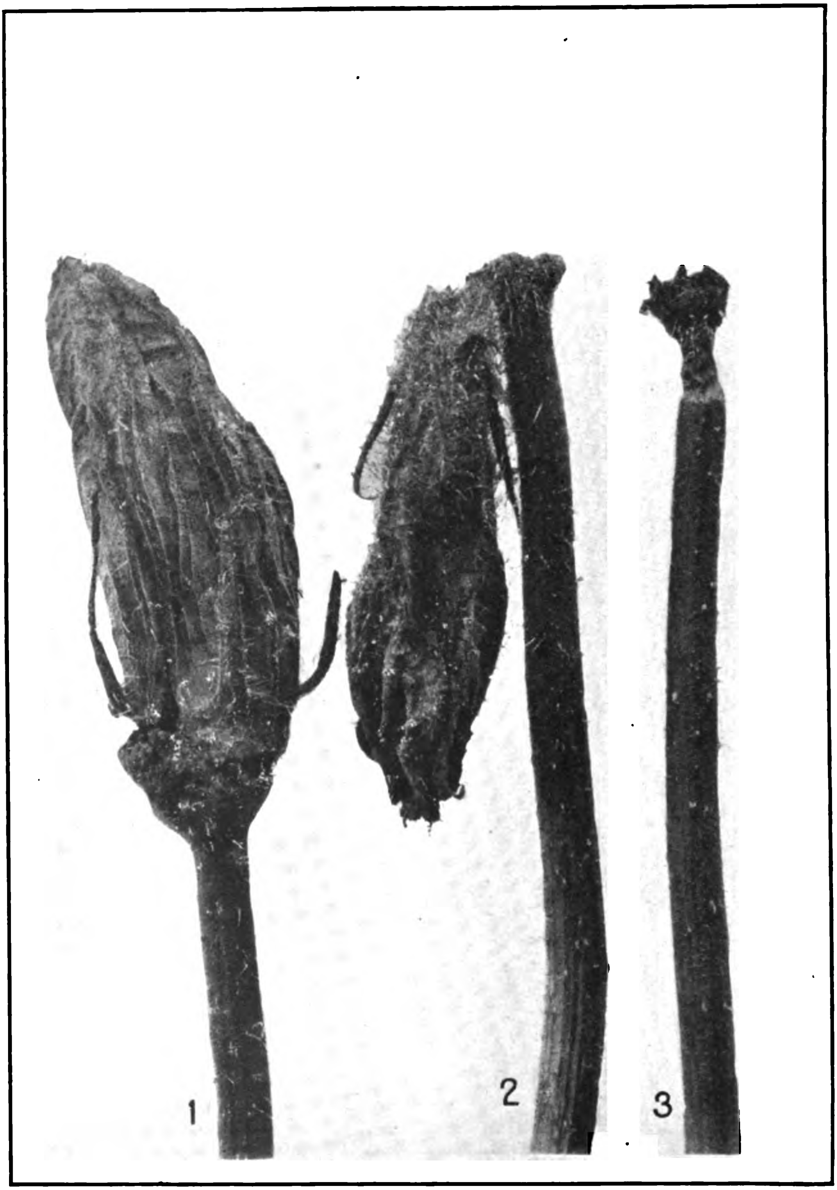
Squash vines affected by the larvæ of the melon fly. Sometimes, especially during wet weather, the female fly deposits eggs in the older stems. The young larvæ hatching do not seem to be able to kill the vine outright as they do the more succulent and rapidly growing vines, but as they mature they cause abnormal swellings to develop about them. As the vines throw out rootlets little injury is caused to squashes by this method of attack. (Original.)



MELON-FLY EGGS DEPOSITED IN BLOOMS OF PUMPKIN.

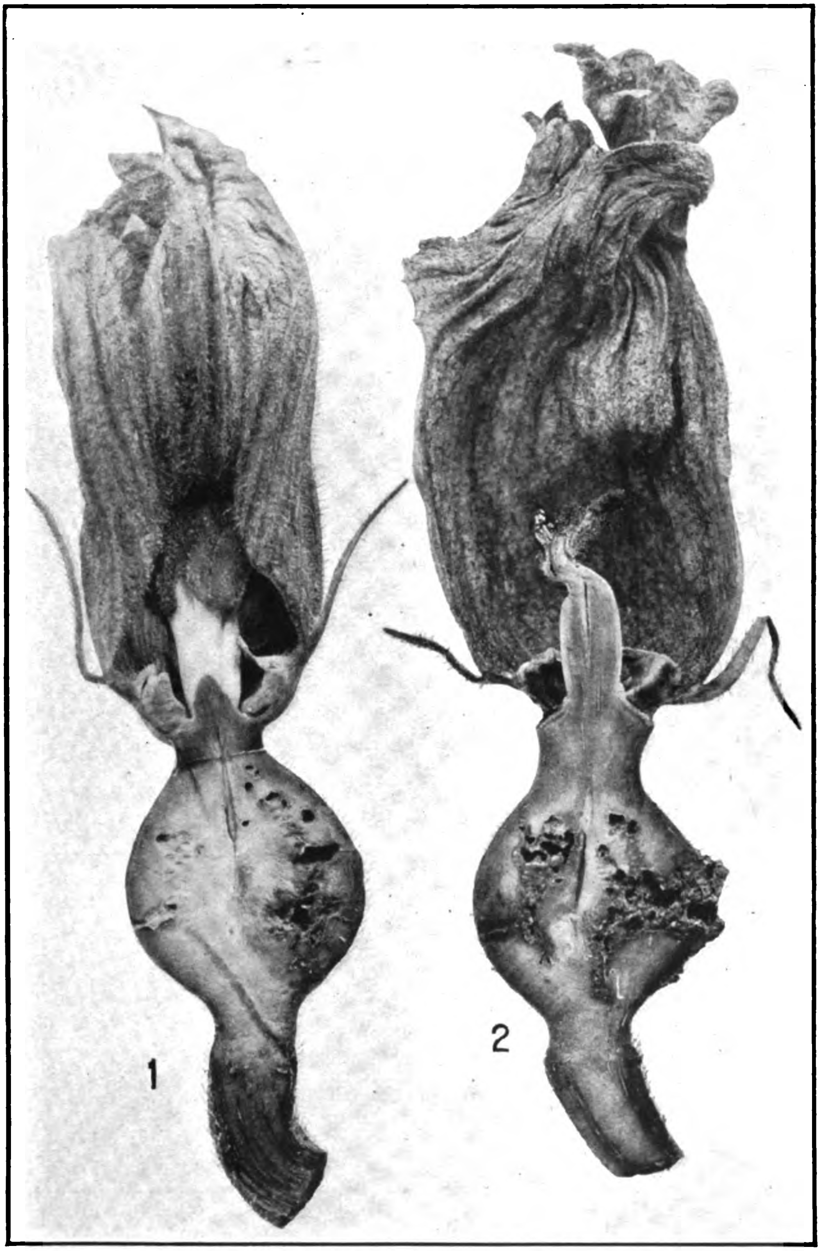
Two buds of the male bloom of pumpkin sectioned to expose melon-fly eggs deposited through the corolla. Note that larvæ from eggs already hatched are causing the destruction of the vital organs. (Original.)

PLATE VIII.



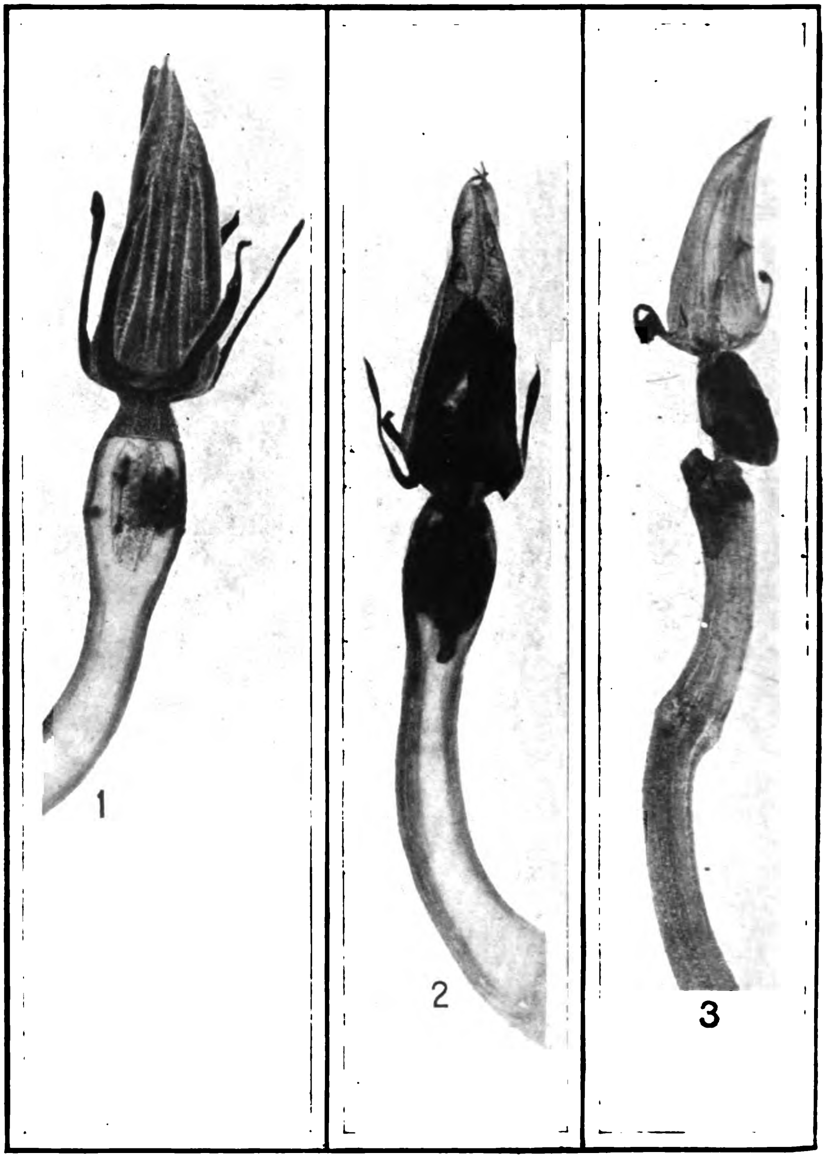
RESULT OF INFESTATION OF PUMPKIN BLOOMS BY LARVÆ OF MELON FLY.

**Buds of the male flowers of pumpkin affected by the larvæ of the melon fly. Figures 1, 2, and 3 represent the various stages in the destruction of the male bloom after the larvæ hatching from the eggs shown in Plate VII have begun to develop. In figure 1 the larvæ have destroyed the pollen and are devouring the receptacle. In figure 2 the inflorescence is hanging and the larvæ are still within, while figure 3 represents the final stage of destruction. During the warmer months of the year practically all male flowers are affected, although many succeed in blooming. (Original.)**



WORK OF LARVÆ OF MELON FLY IN BLOOMS OF PUMPKIN.

In figures 1 and 2 is shown the work of the larvæ of the melon fly in bringing about the destruction of the ovaries of pumpkin bloom even before the corolla has entirely withered. Note that in figure 1 the corolla has not yet unfolded nor has the stigma been exposed. In figure 2 is shown the more complete destruction of the ovary of a flower, the corolla of which has but recently withered. (Original.)



DAMAGE TO SQUASH BY LARVÆ OF THE MELON FLY.

Cross sections of unfertilized ovaries of three squash fruits showing a type of infestation, progressing from figure 1 to figure 3, that brings about the complete destruction of the crop of many acres of squashes and pumpkins where no care is taken to guard against oviposition. Note that the slight infestation of figure 1 has extended up into the pistil of figure 2, while in figure 3 the larvæ have worked so rapidly that the ovary is breaking before the corolla can unfold. (Original.)

*Injury to the foliage and stems.*—The very disastrous effects of attack on the foliage is shown in Plate I, figure 1, where the petiole of a watermelon seedling has been tunneled by larvæ. Such complete destruction is not usual in older plants after the tissues have hardened. Larvæ developing in the pipelike petioles of large pumpkin leaves do almost no harm. The manner in which developing runners of watermelon seedlings may be killed back to the crown is illustrated by Plate XXI, figure 3. As the plants become older the crown becomes so toughened that it withstands attack, the growing tips of the vines, especially those of watermelon and cantaloupe, are seriously attacked, and the larvæ developing in the shoot cause its death beyond the point of infestation, as shown in Plate II, and thus bring about a progressive pruning. At the time infestation illustrated in Plate II occurred the growing shoot was so small that the puncture made by the female for her eggs practically cut the shoot and would have produced withering beyond had no further destruction been caused by the larvæ developing later. In Plates III and IV may be seen the type of injury to still older watermelon shoots. Note that the young fruit has begun to wither and that the stalk has already turned black and has become flabby to the touch, thus indicating that the interior has been destroyed. This destruction of the interior is shown by the shoot on Plate IV, which has been sectioned to expose the well-grown larvæ within. Such pruning back of foliage and shoots appears to occur more often among older cantaloupe vines than among watermelon vines of similar age. In Plate V is given, by way of illustration, a portion of a cantaloupe vine cut in the environs of Honolulu, showing attack in eight places. The field from which this vine was taken bore only small, stunted vines, in spite of the fact that the soil was rich.

Oviposition in the stems of host plants does not always produce the complete destruction illustrated, since very often the growth of plant tissues may be so rapid that the larvæ appear to be killed. Again, they are able to develop locally, reach their full development, and leave the plant without having affected vital injury. Under these conditions, however, the plant may develop an abnormal growth about the feeding larvæ. These abnormal developments of the vine have never been observed in any host plant but the pumpkin and squash, and then reach their fullest development only during wet weather. (See Pl. VI.) During dry weather, when the vines are tougher, little successful infestation of squash or pumpkin vines occurs.

*Injury to the bloom.*—It is difficult during the greater portion of the year in littoral Hawaii, especially on the island of Oahu, to find an unaffected pistillate flower of any cucurbitaceous host plant growing naturally in the field. No staminate blooms of watermelons, cantaloupes, cucumbers, and certain Chinese marrows have been found affected, but those of the pumpkin and squash varieties are badly attacked. An examination of 207 well-developed buds of the male flowers in a field at Waialua during March, 1915, proved each bud to contain the eggs or larvæ of the melon fly. Plate VII represents the early stage of infestation of the male bloom of pumpkins. As the larvæ hatch they feed upon the receptacle and the anthers until the interior is a mass of decay. In the illustrations of Plate VIII are shown three stages in the destruction of the male bloom. In figure 1 the larvæ have destroyed the anthers and are burrowing about the receptacle; in figure 2 the continued work of the larvæ and the weight of the bud have caused the latter to break over, while figure 3 represents a very frequent condition after the bud has dropped to the ground, leaving behind a few larvæ within the upright flower stalk and carrying others within itself to the ground. When the male bloom is attacked late in its development the corolla unfolds normally, exposing to view unhatched eggs or very young larvæ on its inner surface or among the pollen grains. When buds are attacked before they are three-fourths developed they usually are destroyed before they can bloom. Eggs are never deposited in the flower while it is in bloom.

While injury to the corolla of the female bloom does occur in pumpkins to a limited extent, the attraction of the unfertilized ovaries is so much greater that this portion of the bloom receives the greater amount of oviposition, and infestations that prevent blooming occur within the ovaries rather than in the corolla and about the style and stigma. The greatest injury to pumpkin, squashes, watermelon, cantaloupes and *Momordica* spp. occurs at this stage, or directly before and after the flower unfolds, and is, to the uninformed, so obscure that the apparent sterility of fields of rankly growing vines is often the cause of discussion. The cross-sections of the bloom of pumpkins in Plate IX illustrate the disastrous result of this attack. In figure 1 the ovary has already been ruined by young larvæ before the corolla has opened to expose the stigma for fertilization. In figure 2 is shown a more advanced stage of infestation, but one occurring before the corolla has entirely withered or lost its color. The three figures on Plate X illustrate the progressive infestation of the pistillate bloom of squash. In these examples the larvæ have not only attacked the ovaries, but, as in figure 2, have worked their way up into the corolla. Often, in blooms of this type, the work of the larvæ, aided by decays started by them and the weight of the upper portion of the bloom, causes the ovaries to break off, as illustrated in figure 3. Such destruction is almost complete in uncared-for fields of all cucurbits except the cucumber, which rarely is attacked until after the fruits are well set.

*Injury to the fruits after fertilization.*—All degrees of injury will be found among the fruits of host plants. The younger the fruits, as a rule, the more susceptible they are to complete destruction by the larvæ and subsequent decays. If infestation is serious directly after the bloom has withered, particularly among watermelons in a dry location, a mummification of the fruits may result. (Pl. XI, fig. 1.) The completeness with which the young watermelons may be destroyed before mummification is shown by Plate XI, figure 2. Still older watermelon fruits may become badly infested, as illustrated by the longitudinal section in Plate XII and the cross-section in Plate XIII. In the latter the interior bearing the seeds had been reduced to a watery mass and the larvæ were found burrowing through the rind. In fruits such as those illustrated in Plates XII and XIII secondary decays soon bring about a complete destruction of the host.

The injury caused by the developing larvæ may not be so great as completely to destroy the host fruit. In such cases, especially among pumpkins and squashes, which are apt to develop a corky protective growth over the surface exposed by infestation, various and curious deformities are produced as illustrated by the young fruits shown in Plate XIV. In each of these fruits one or more colonies of melon-fly larvæ have reached maturity and emerged. The figures in Plates XV and XVI illustrate several types of injury to very young pumpkins. While these fruits will persist on the vines for several weeks during dry weather, they ultimately succumb to the secondary attacks of scavenger insects and decays.

As the fruits become larger, before they are attacked, they may show almost no indication of infestation to the casual observer, although there never is any doubt in the mind of a trained observer. An examination of such fruits may reveal the interior to be badly affected and eaten out, although the exterior remains firm. This is probably true more in the case of cucumbers and several varieties of Chinese marrows (*Momordica* spp.), and less so of string beans, as illustrated in Plate XVII. Injury to tomatoes, when the larvæ become about half grown, is usually accompanied by decay confined for some time to the section of the fruit affected.

*Deformities resulting from punctures of the epidermis when no eggs are deposited, or from infestations by larvæ or eggs in only the outer portion of the rind.*—Deformities of all sorts are produced in cucumbers and pumpkins which have been attacked late in their development. Deformities among watermelons have been noted by the writers chiefly in small fruits as illustrated in Plate XVIII, figures 1 and 2. Deformities among cucumbers and squashes are illustrated in Plates XIX and XX. These injuries are most often the result of the irritating presence of batches of eggs or small colonies of larvæ present in the extreme outer portion of the fruit. Such deformities are serious injuries, as they prevent the full normal expansion of the fruit during growth, as will be appreciated when a comparison is made between figures 2 and 3, Plate XX, illustrating a badly deformed and a nearly perfect squash. Among watermelons and gourds deformities usually follow mortality among eggs and very young larvæ, discussed elsewhere (page 46), but among pumpkins and squashes they may develop about open wounds made by larvæ, as illustrated in Plate XX, figure 1. Early infestation of bean pods is evidenced frequently by a constriction in the pod at the point of oviposition.

## FOOD PLANTS.

The food plants of the melon fly may be divided into those preferred and those occasionally infested and may be listed as follows:

### PREFERRED, CULTIVATED.

1. Cantaloupe.
2. Watermelon.
3. Pumpkin.
4. Squash.
5. Gourds.
6. Chinese cucumber (*Momordica* sp.).
7. Chinese melon.
8. Cucumber.
9. Tomato.
10. String beans.
11. Cowpeas.

### OCCASIONALLY INFESTED, CULTIVATED.

1. Eggplant.
2. Water lemon (*Passiflora*).
3. Orange.
4. Fig.
5. Papaya.
6. Peach.
7. Mango.
8. Citrullus (Java).

### WILD.

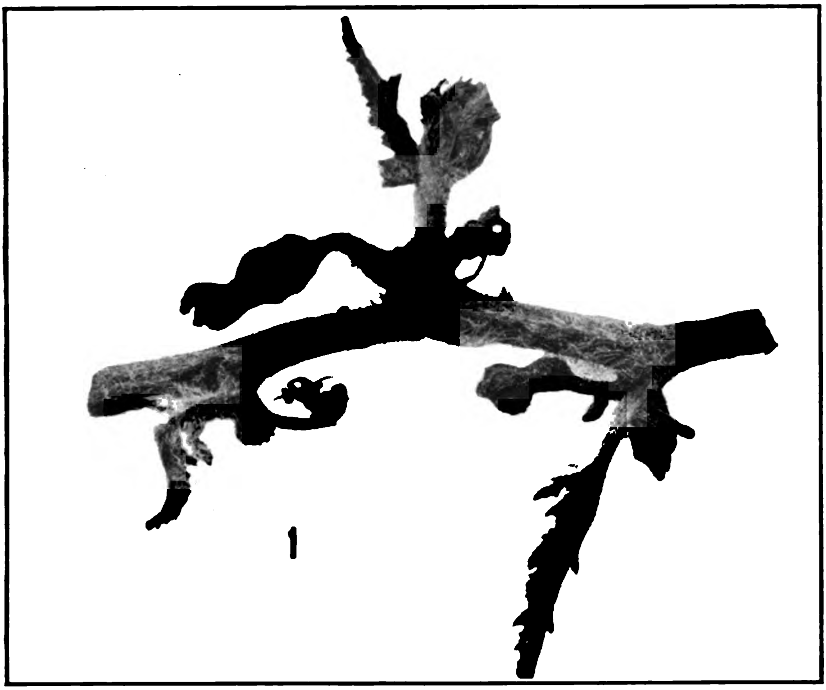
1. *Sycos* sp.
2. *Momordica* sp.

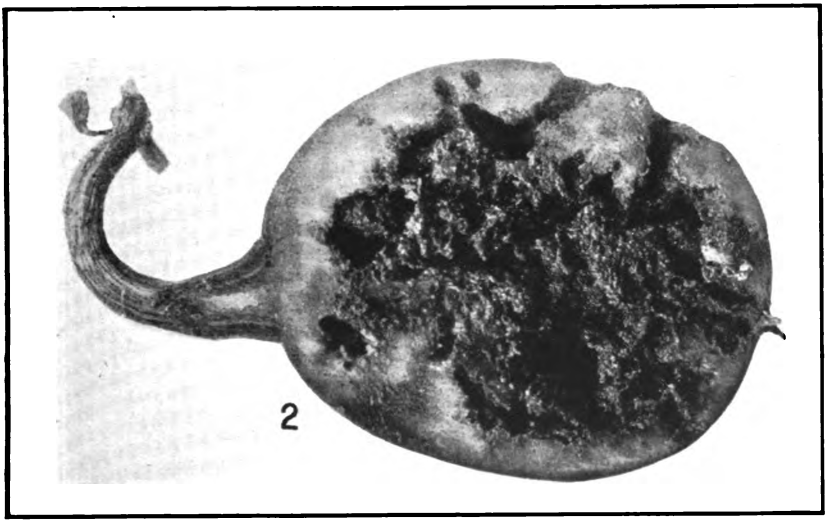
### ERRONEOUSLY RECORDED HOST FRUITS.

1. Kohlrabi.
2. Cabbage.
3. Peppers.

## CUCURBITACEOUS PLANTS.

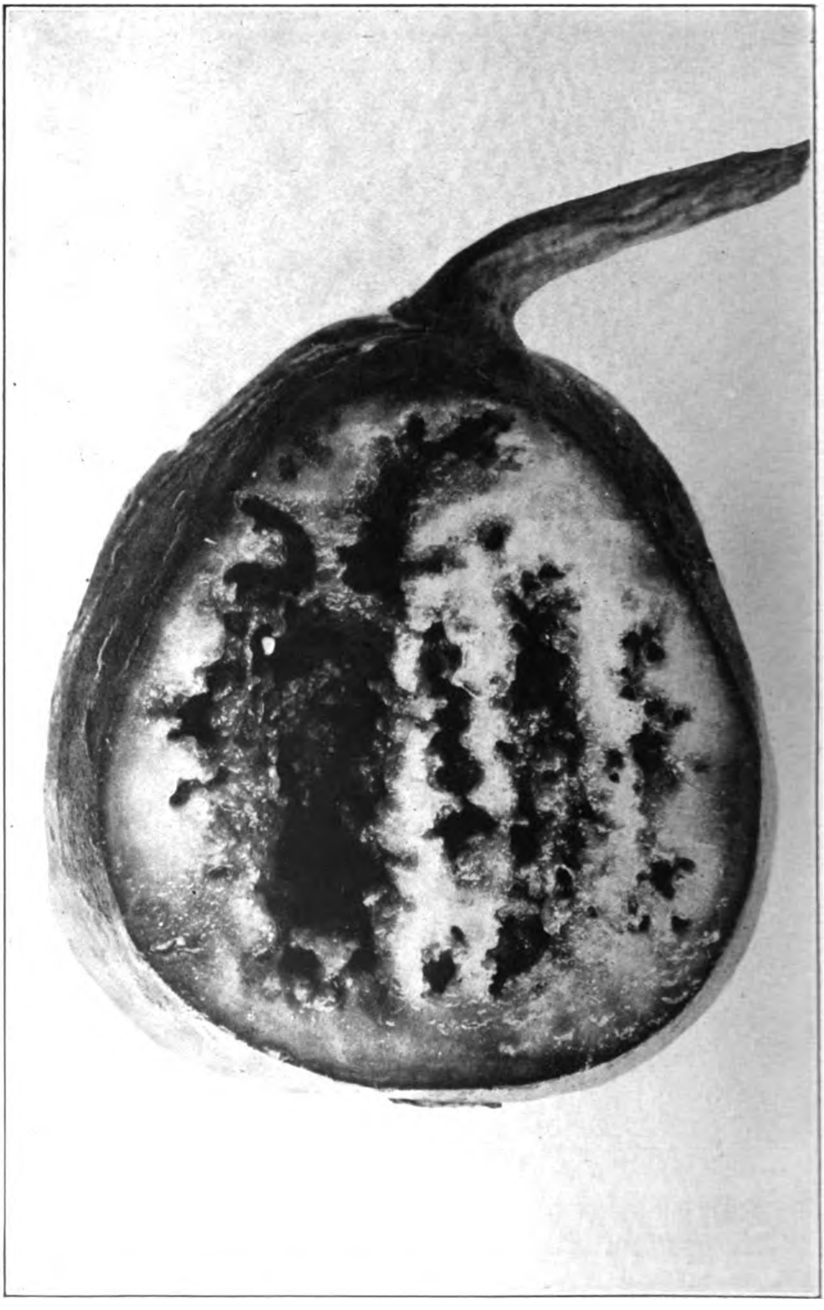
All the cucurbitaceous plants are subject to severe infestation, particularly of the young fruits. Cantaloupes are the most susceptible, since the vines as well as the fruit are badly attacked at all stages of growth and the fruits do not appear to develop the resistance to attack found among the older watermelons, pumpkins, and squashes. The ordinary cucumber is the most resistant to





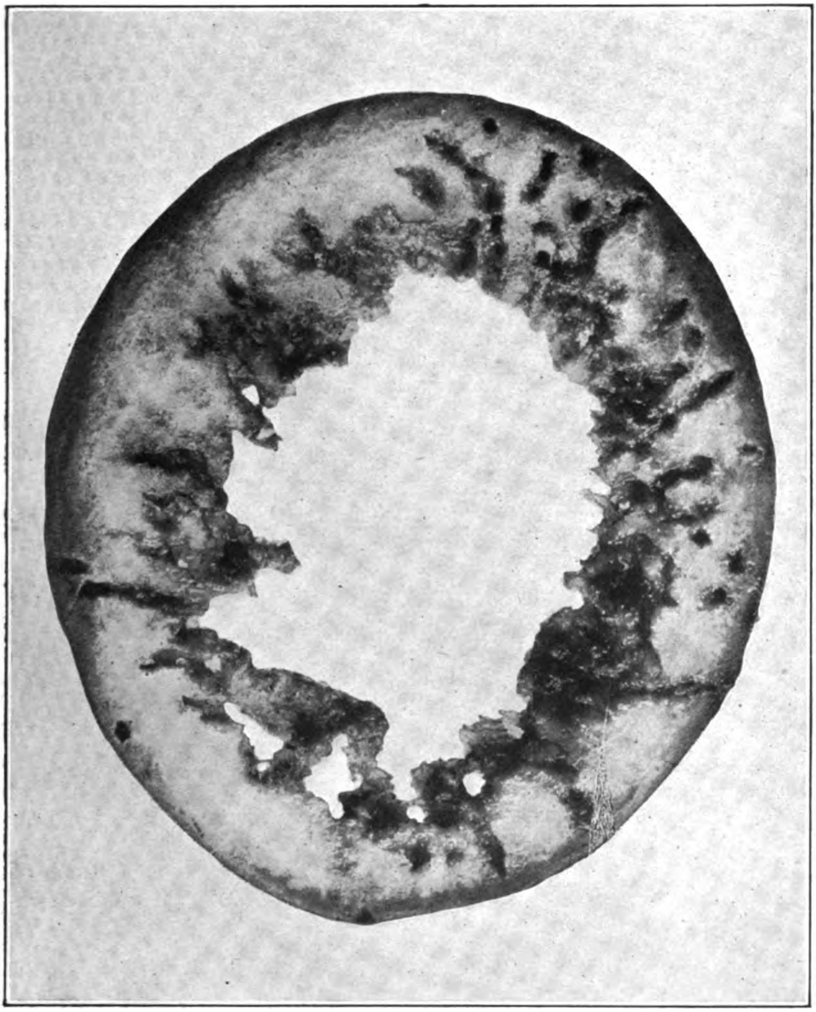
DAMAGE TO WATERMELON BY LARVÆ OF MELON FLY.

In figure 1 is shown the mummification of young watermelons before the bloom has unfolded, caused by larvæ which have already developed and left the fruit to pupate in the soil. The complete destruction of the young fruit before mummification begins is shown in figure 2. (Original.)



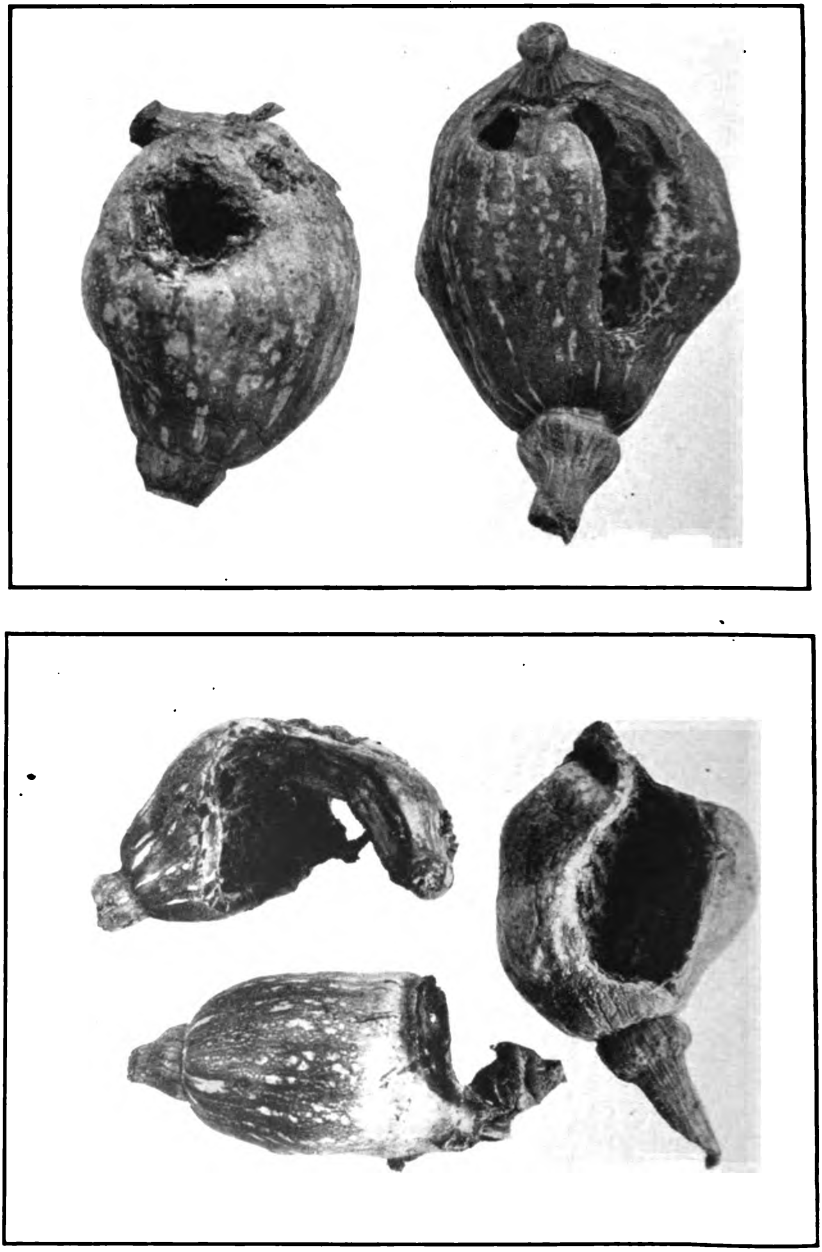
DAMAGE TO WATERMELON BY LARVÆ OF THE MELON FLY.

Longitudinal section of a young watermelon showing destruction of interior by larvæ of the melon fly. About natural size. (Original.)



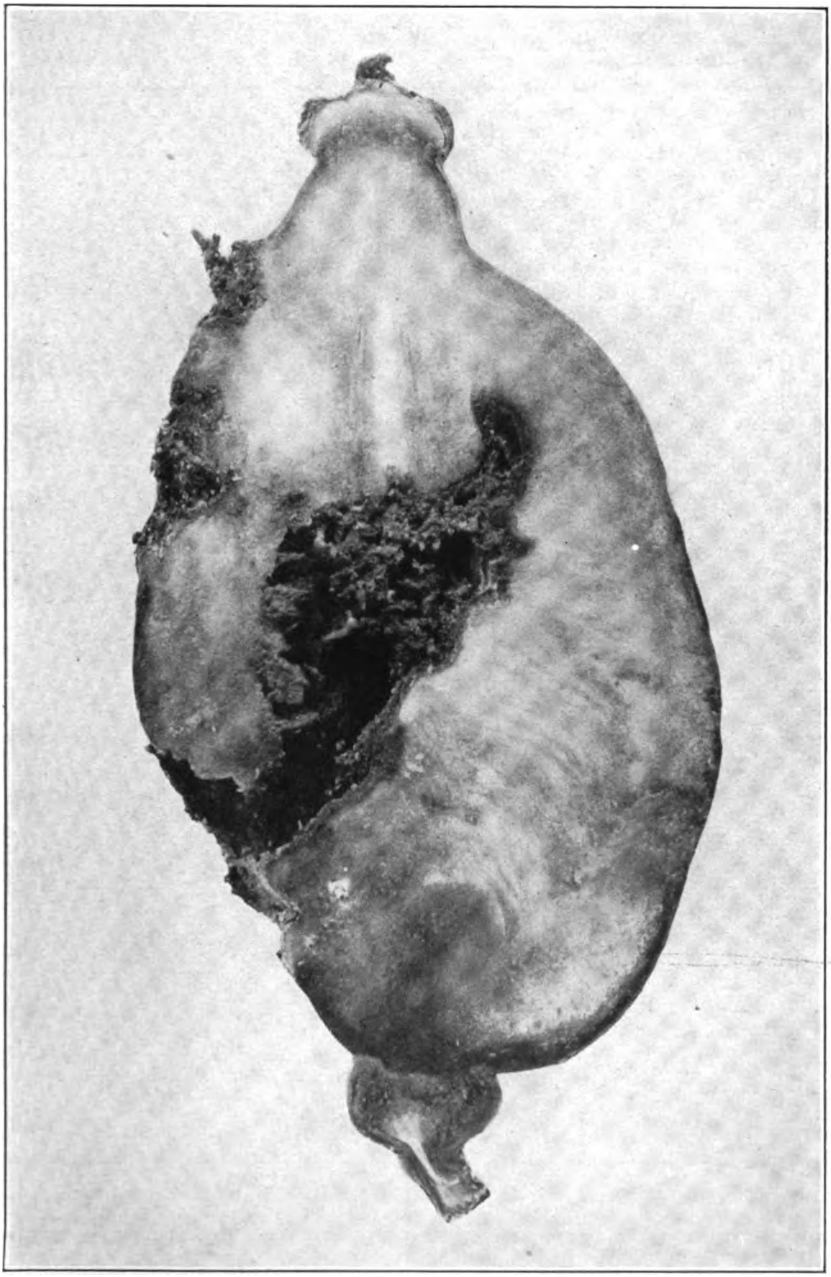
DAMAGE TO WATERMELON BY LARVÆ OF MELON FLY.

**Cross section of watermelon showing complete destruction of interior by the larvæ of the melon fly. Note that the larval tunnels extend through the rind in all directions and that the edible portion has been completely broken down. (Original.)**



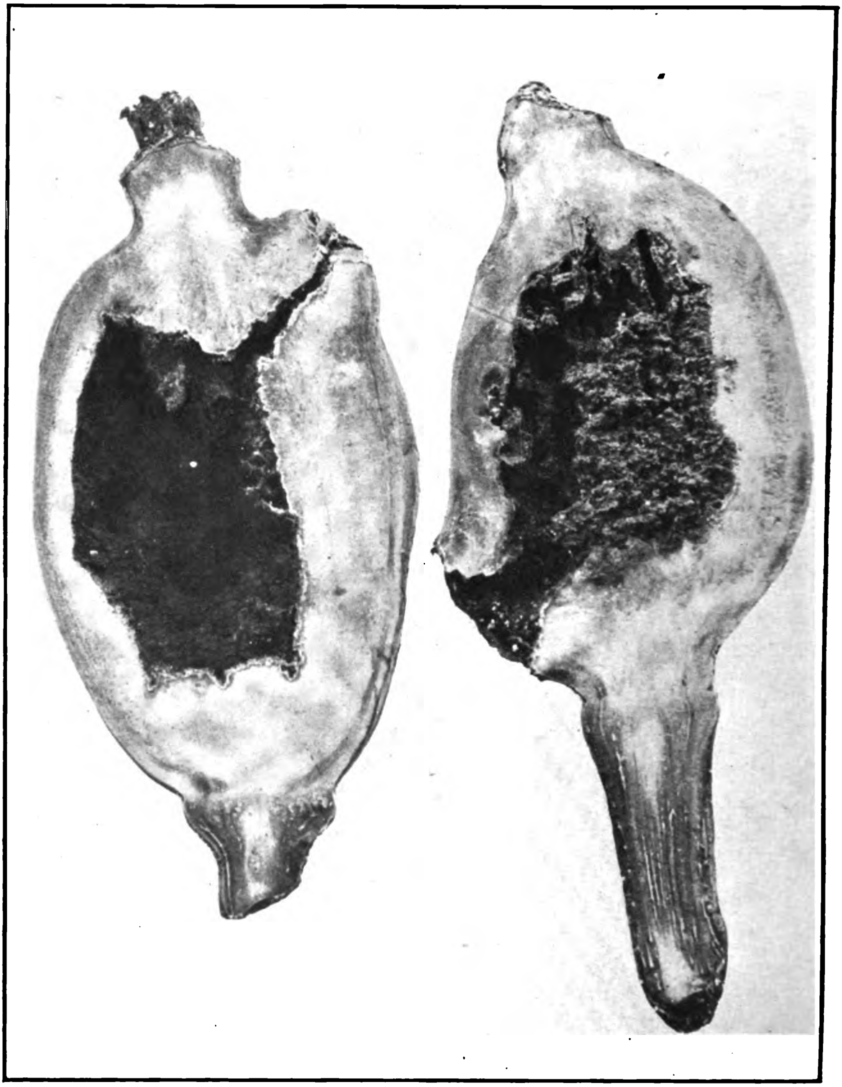
DEFORMED PUMPKIN FRUITS CAUSED BY LARVÆ OF THE MELON FLY.

Various deformities of very young pumpkins caused by infestation started before or just after fertilization of the ovary. These fruits persist for a time, due to callouses developing about points of attack, but they never reach a much larger size and are ultimately destroyed by fungi and secondary insect attack. (Original.)



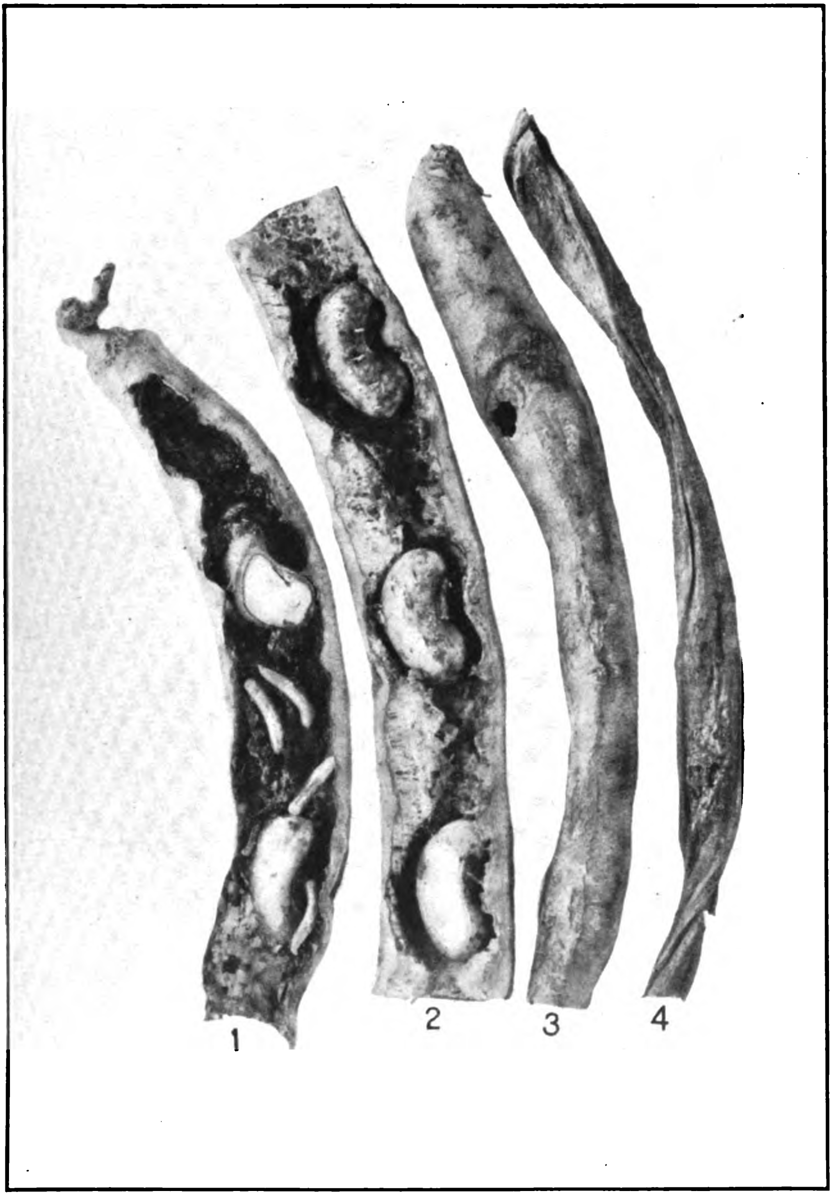
WORK OF LARVÆ OF MELON FLY IN YOUNG PUMPKINS.

Cross section of young pumpkin. Each affected area represents the location of a colony of larvæ of the melon fly. (Original.)



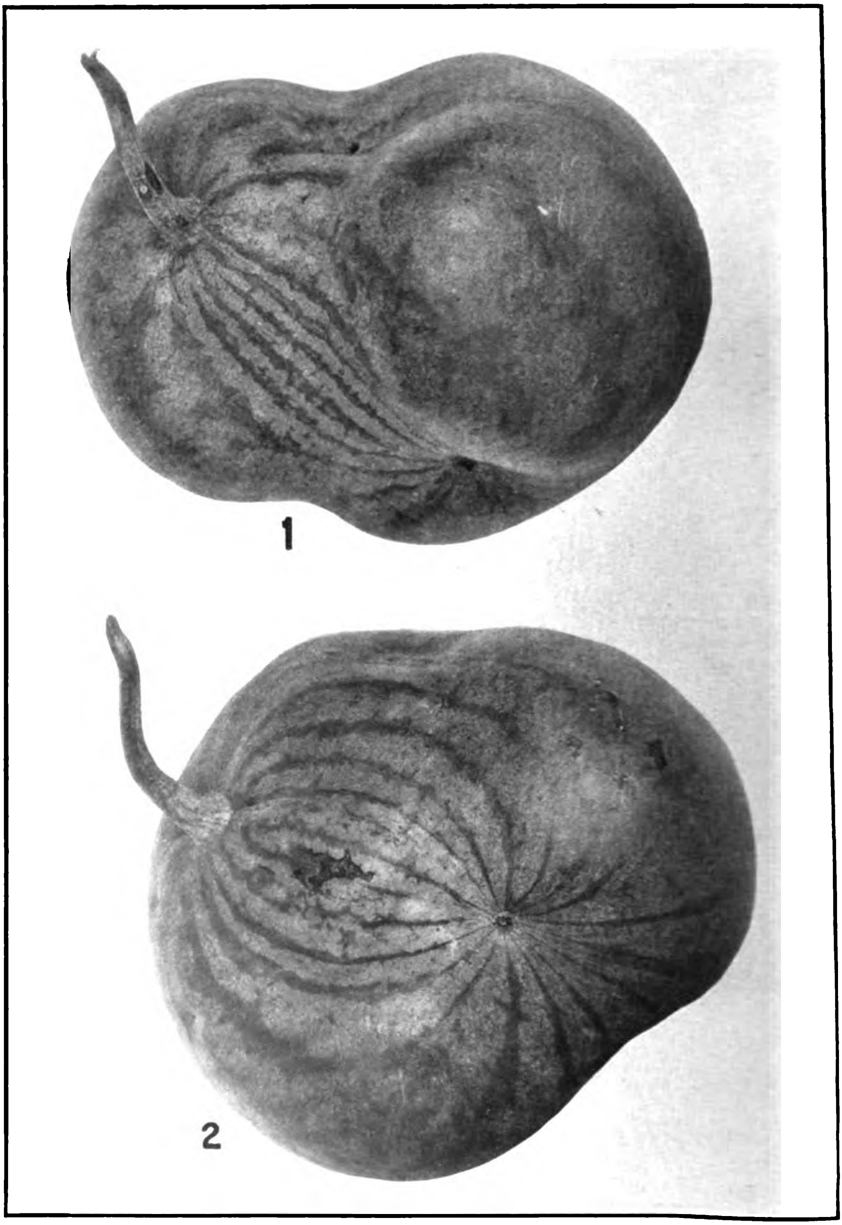
WORK OF LARVÆ OF MELON FLY IN YOUNG PUMPKIN.

Cross section of two young pumpkin fruits. In these the larvæ of the melon fly have reached full growth, and have left by the only opening to the exterior, which is also, in both instances shown, the point of original infestation. (Original.)



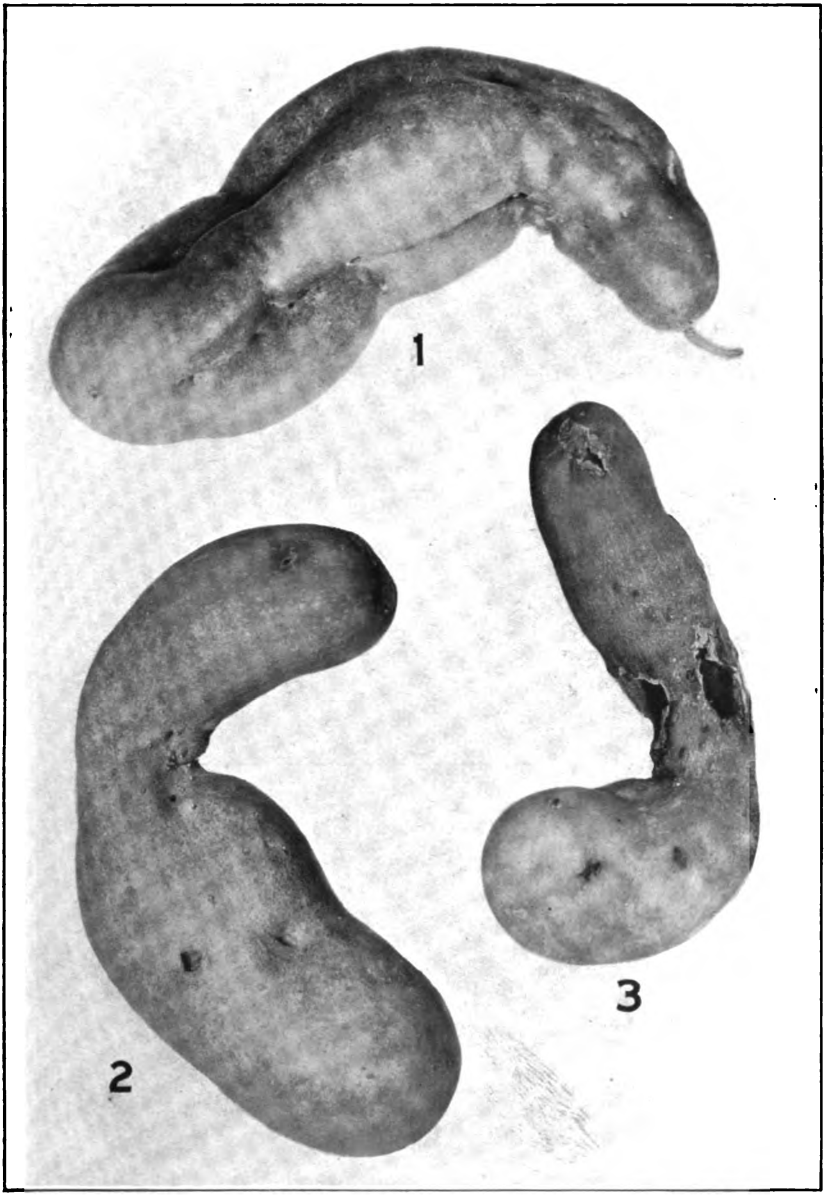
WORK OF LARVÆ OF MELON FLY IN GREEN BEAN PODS.

Bean pods affected by larvæ of the melon fly. In figures 1 and 2 a portion of the pod has been removed to expose the larvæ within and their work. Figures 3 and 4 represent pods in different stages of drying out after well-grown larvæ have left them. (Original.)



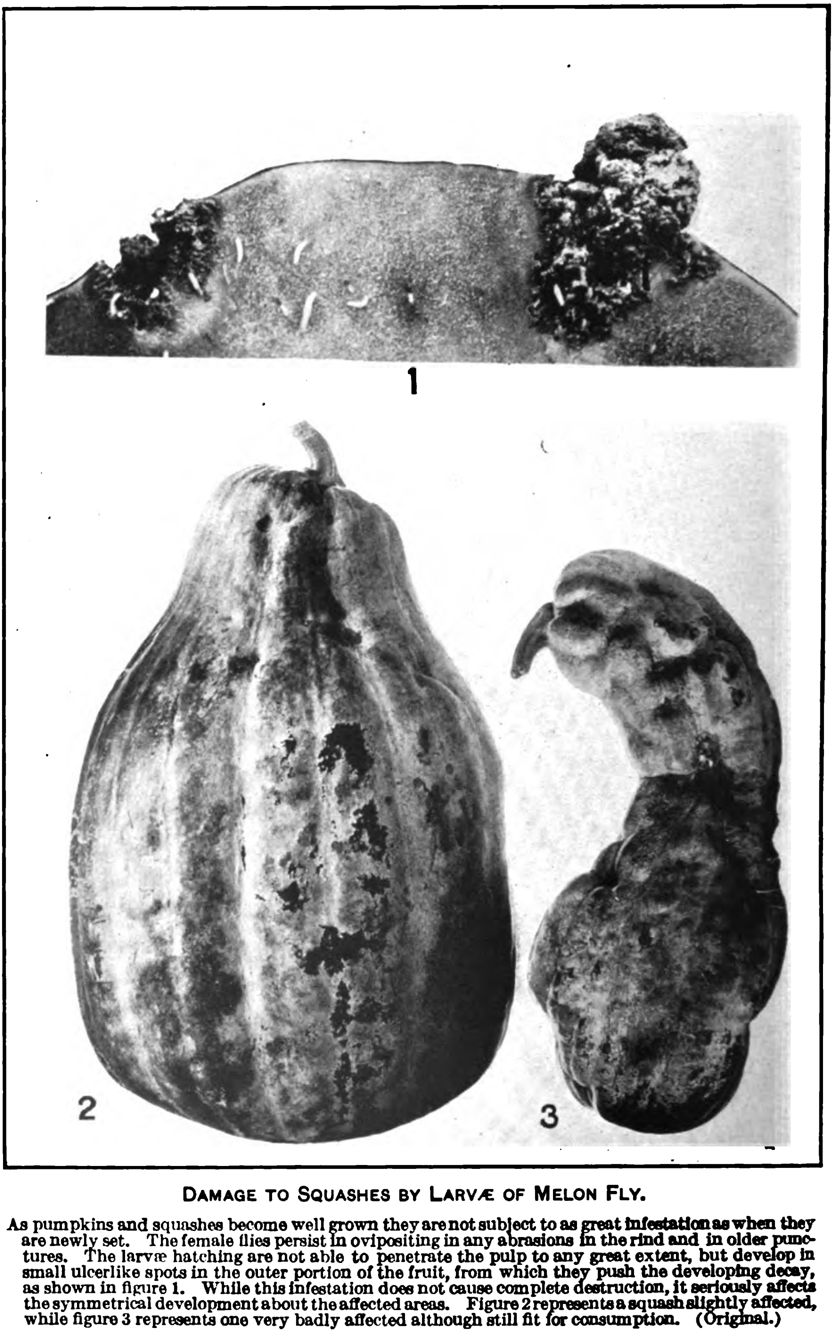
Deformed Watermelons Resulting from Late Infestation by Larvæ of Melon Fly.

Often during the cooler months watermelons become infested so late in their development that the larvæ can not penetrate the pulp and often die within the egg chamber. The development of the fruit about these affected areas is arrested and various deformities result, as shown in figures 1 and 2. (Original.)



DAMAGE TO CUCUMBERS BY LARVÆ OF MELON FLY.

Cucumbers affected by melon-fly attack seldom become infested until after the bloom has withered. Nearly all fruits offered for sale in Honolulu markets show various deformities or imperfections caused by oviposition. Frequently fruits maintaining a firm exterior appearance are badly infested within, as were those of figures 1 and 2. (Original.)



DAMAGE TO SQUASHES BY LARVÆ OF MELON FLY.

As pumpkins and squashes become well grown they are not subject to as great infestation as when they are newly set. The female flies persist in ovipositing in any abrasions in the rind and in older punctures. The larvæ hatching are not able to penetrate the pulp to any great extent, but develop in small ulcerlike spots in the outer portion of the fruit, from which they push the developing decay, as shown in figure 1. While this infestation does not cause complete destruction, it seriously affects the symmetrical development about the affected areas. Figure 2 represents a squash slightly affected, while figure 3 represents one very badly affected although still fit for consumption. (Original.)

attack when very young, although one rarely sees fruit offered for sale in Honolulu that does not show some evidence of attack even when very carefully selected. Cantaloupes and cucumbers may be successfully oviposited in by the female fly up to the time they are ready for market. While cantaloupe growing has been practically abandoned in Hawaii since the advent of the melon fly, cucumbers are grown without protection of any sort. Although practically all fruits reaching a size fit for salad use show evidences of attack at one or more spots, the percentage of fruits rendered unmarketable is not large enough to force the oriental growers to cover the young fruits, although it would appear disastrously large to American market gardeners, who place a high value on their time. During midwinter 150 out of 153 cucumbers ready for the market at Moiliili were found variously infested.

All cucurbits grow with such rapidity in Hawaii that the oriental is willing to permit the pest to destroy fully 50 per cent of the fruits rather than go to the expense of covering each fruit as soon as or before it sets. All other cucurbits except cucumbers must be covered before or just after blooming to prevent wholesale injury. Aside from the fact that the seedlings and vines of all cucurbits except cantaloupe and watermelon are but slightly attacked, there is little difference in the susceptibility to attack of the young fruits under Hawaiian conditions. Inasmuch as the fly has been permitted to increase unchecked since its introduction, it has become so abundant that slight differences in inherent resistance to attack are not evident among host fruits growing in the field. The infestation is excessive in all unprotected fruits. If by chance pumpkins, squashes, and watermelons escape infestation until they are from 4 to 6 inches in diameter they may reach maturity, although before they reach maturity pumpkins and squashes may support numerous colonies of larvæ in open-surface wounds (Pl. XX, fig. 1), and become badly deformed. Out of 254 nearly full-grown pumpkins growing at Kahuku, 250 were found variously deformed by H. F. Willard on March 21, 1915. As many as 650 adults have been reared from a pumpkin no more than 4 inches long; the staminate bloom while still a bud may support as many as 37 well-grown larvæ.

### TOMATOES.

Tomatoes are very susceptible to attack. All tomatoes offered for sale in Honolulu are apt to be infested, as shown by the reports of the market fruit-fly inspector covering several months. Fifteen ripe and partly ripe fruits examined by H. F. Willard at Hauula on March 21, 1915, were found to contain eggs or larvæ. Such severe infestation is so general during the warmer months that data are superfluous. The tomato under climatic conditions less favorable for the increase of the melon fly would probably be found to be less susceptible to attack than cucurbitaceous crops. The fruits of the currant tomato (*Solanum pimpinellifolium*), the grape tomato (*S. lycopersicum*), the popolo (*S. nodiflorum*), and the spiny yellow-fruited Solanum common in Hawaii are all found growing about fields of cucurbitaceous crops, but the writers have never yet found them infested. During January and February the writers have seen fields of tomatoes producing a large percentage of sound fruits. Only the fruits of the tomato are subject to attack.

### STRING BEANS.

The ordinary varieties of string beans grown on the mainland are not as a rule infested by the melon fly. Three hundred and seventy-five pods sufficiently ripe to have turned color, of the variety commonly known as the yellow wax bean, were examined at Haleiwa in March and were found free from attack, although growing close to a field of badly affected pumpkins. Examinations of string beans in other localities, particularly about Honolulu, indicate that only seldom are any of the varieties affected except the more fleshy, long-podded Chinese variety. This variety may be very badly attacked when grown near other favored host fruits or on land recently cleared of such crops. (See Pl. XVII.) As many as 36 well-grown larvæ have been found within a single pod.

Although the Chinese variety is the only one at times generally and badly affected, beans of all varieties except the lima bean should be included in quarantine lists. The lima bean has never been found infested. Only the pods of beans are usually affected. The larvæ prefer to feed upon the fleshy portions of the pod, but sometimes attack the seeds. In badly infested pods, attacked before the seeds are well grown, the larvæ may eat out the seeds, leaving the outer portion untouched. This is also true of cowpeas.

### COWPEAS.

Although cowpeas are not grown to any extent in Hawaii, they are subject to melon-fly attack. Only the pods are affected. The writers have removed as many as 37 larvæ from a single pod. When infestation occurs early the young seeds may be devoured, but attack is more often centered upon the pod itself. There is a distinct varietal difference in the susceptibility of cowpeas. Upon this notes were made, but unfortunately have been lost.

### EGGPLANT.

Froggatt (26) in 1909 reports that he and F. H. Howlett reared the melon fly from maggot-infested melons, cucumbers, bitter gourds, and eggplant. Maxwell-Lefroy (18) in 1907 and Fletcher (43) in 1914 do not mention the eggplant among the host plants of the melon fly. Fullaway (44) in 1913 lists the eggplant among garden crops affected by the melon fly, and Severin (45) in 1914 gives data on the length of the egg and larval stages in eggplant and lists this plant as a host, although he does not state that he found it normally infested in the field. Experimental work was undertaken to determine to what extent, if any, infestation occurs in the field and under forced conditions in the laboratory. Sound well-grown fruits were placed in jars containing females which had been ovipositing regularly in tomatoes. No eggs were laid in these fruits. One fruit containing a soft, slightly decayed spot on one side was similarly placed with ovipositing females for one day. Eggs were deposited in the decayed area only and later 9 flies emerged. A muskmelon allowed to hang in a jar containing females for an hour would have produced several hundred or more flies.

One hundred and fifteen fruits of all ages taken April 26 to 30, 1914, from a field at Moiliili showed no evidence of infestation when on May 2 to 5 they were examined by removing the skin for the detection of egg punctures and larval chambers. Ten fruits picked at Mokuleia on April 18, 1914, from the midst of badly infested private gardens, showed no infestation when held individually over sand in glass jars. One thousand fruits of all sizes and conditions of ripeness and soundness were examined by the junior writer during November, 1915, by carefully removing the skin of each fruit and examining with a lens all decayed spots. No melon-fly larvæ were found, although in one fruit directly beneath the skin were found several well-grown larvæ of the Mediterranean fruit fly. The senior writer has personally examined superficially during a three-year period many thousand eggplants in the fields of Moiliili, Waikiki, and Waialua districts, Oahu, without once detecting indications of attack. All fruits individually examined by the removal of skin were taken from the midst of badly infested areas where pumpkins and tomatoes could not be grown successfully because of the severity of attack.

### WATER LEMONS (PASSIFLORA).

The fruit of the water lemon (*Passiflora laurifolia*) is found on the Hawaiian markets in season and is not as a rule infested by the melon fly. The writer has never seen infested fruits on the market or on vines growing wild in the mountains. In one instance the partially mature fruits on a vine growing on a private residence in Manoa Valley were badly attacked. While the deposition of eggs in the partially-grown fruits had produced noticeable deformities in shape and cracks in the rind, a few adults were reared from but one fruit. Fully mature fruit exposed on the market is free from attack, as demonstrated by hanging fruits in jars of melon flies. The flies could not puncture the tough hardened rind. Other species of Passiflora occurring about Honolulu (*quadrangularis*, *edulis*, *alata*, and *foetida*) have never been observed infested.

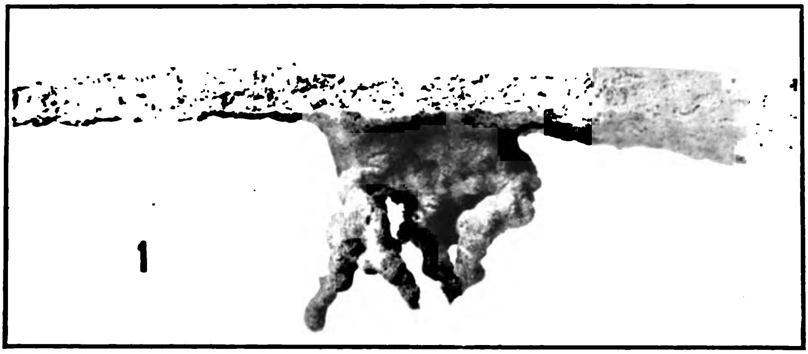
### ORANGE, MANGO, FIG, PAPAYA, PEACH, AND APPLE.

These fruits have never been known to serve regularly as hosts of the melon fly. O. H. Swezy reared adults from figs growing at Kaimuki. E. M. Ehrhorn (29) reared a single female from a sweet orange from the same place. F. W. Terry reared adults from ripe mangoes in August, 1907. Van Dine (19) reports the papaya as a host fruit in 1907. The writers reared a single fly from peaches in 1914. These records of infestation must be considered as exceptional. Of the many thousand peaches and numerous figs, oranges, mangoes, papayas, and other fruits which normally serve as host for the Mediterranean fruit fly that the writers have used to obtain fruit-fly material, none, except the single peach referred to above, have yielded melon flies.

It seems probable that the melon fly will oviposit rarely in these fruits. Larvæ hatching from eggs deposited by females in confinement in apples succeeded in the fruits of softer texture in reaching maturity. Others hatching in apples of firmer texture failed to penetrate the pulp, but crawled out through the puncture opening and died close by it on the surface of the fruit.

### CABBAGE AND KOHLRABI.

Fullaway stated (47) in 1915 that the melon fly had often been reported infesting the heart of cabbage, but that the infestation was not at all common and is considered to be due to abnormal conditions in the plants and of a secondary nature. In 1913 the same writer records cabbage as a host plant. No other writers have reported melon-fly infestations of cabbage. The writers have examined cabbages without discovering melon-fly larvæ. They have frequently found larvæ closely resembling those of the melon fly and from them have reared *Acritochaeta pulvinata* Grims. The larvæ of this fly are found very generally in decaying vegetable matter about gardens in Hawaii. The writers have on several occasions removed them from beneath the sound leaves of cabbage heads, whence they



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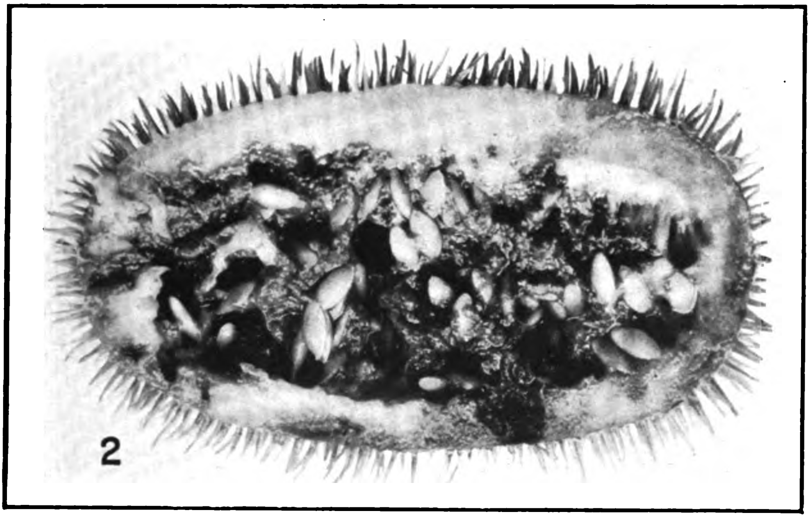

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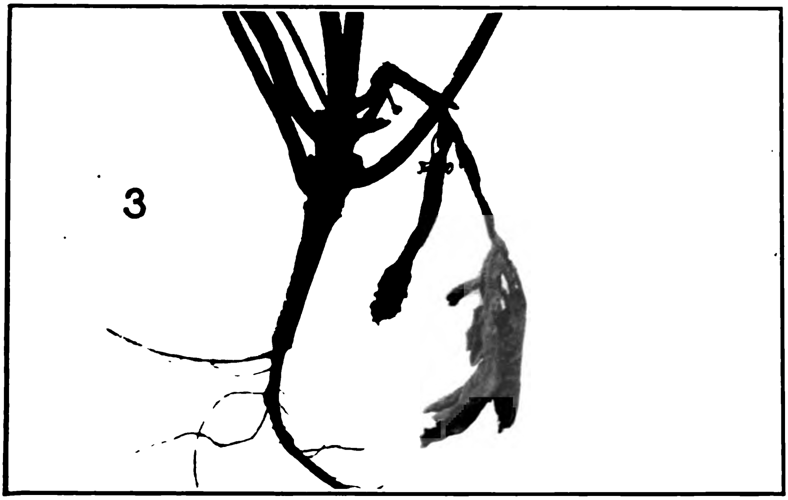
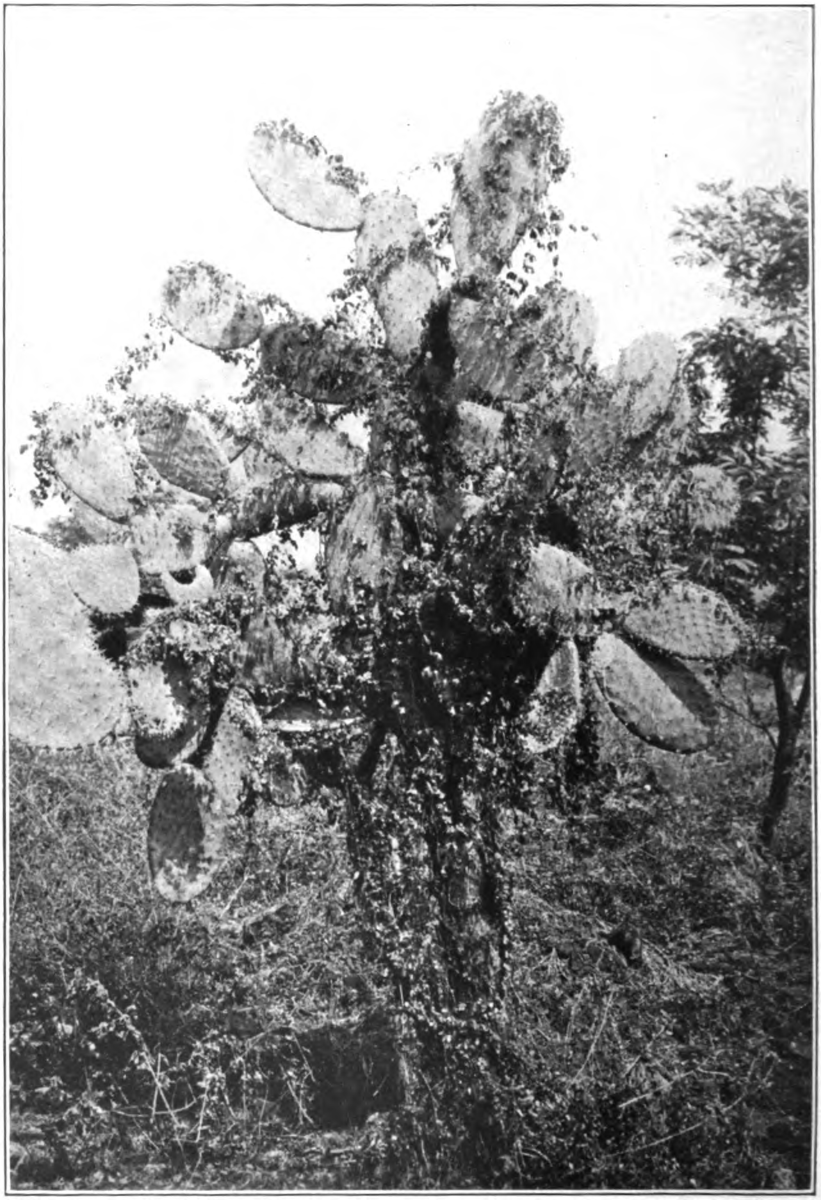


3

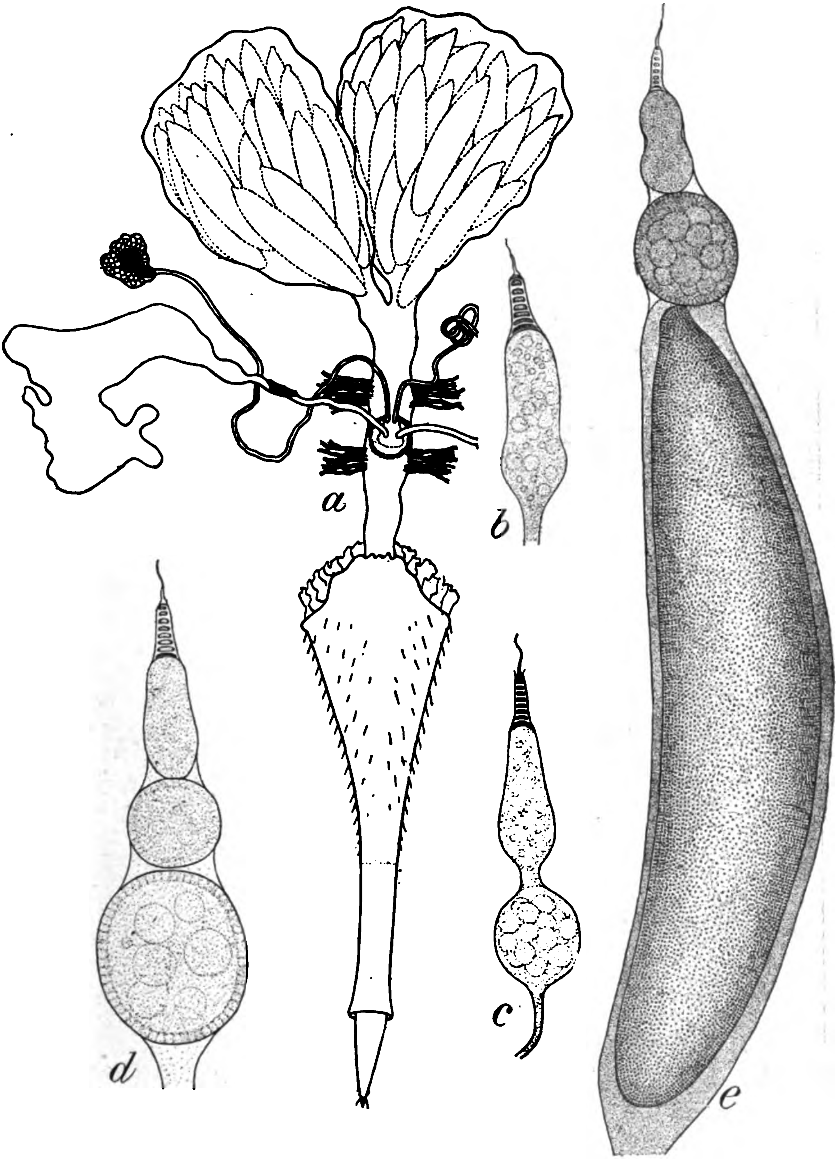
TYPES OF DAMAGE BY LARVÆ OF MELON FLY.

FIG. 1.—Gall-like development formed about the eggs or very young larvæ within a pumpkin. FIG. 2.—Cross section of the wild host *Sycos* sp., showing destruction caused by larvæ. FIG. 3.—Seedling watermelon showing runner killed back by burrowing larvæ. (Original.)



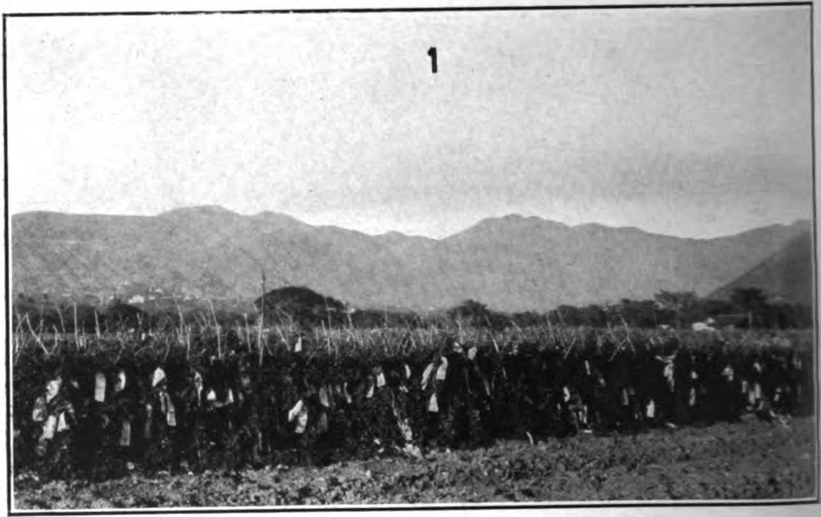
WILD HOST PLANTS OF THE MEDITERRANEAN FRUIT FLY (CERATITIS CAPITATA) AND OF THE MELON FLY (BACTROCERA CUCURBITAE).

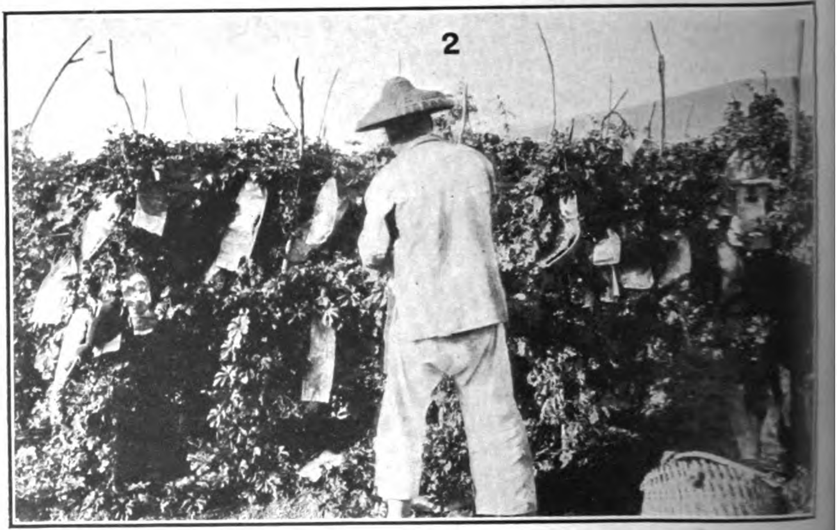
**The cactus (Opuntia) and Chinese cucumber (Momordica) grow wild in pasture lands on the Island of Hawaii, the one furnishing food for the Mediterranean fruit fly and the other for the melon fly. In these two hosts these flies are capable of subsisting in areas unfit for cultivation. (Original.)**



REPRODUCTIVE SYSTEM OF THE FEMALE MELON FLY.

**Reproductive system of the adult female melon fly: *a*, System as a whole; *b*, egg tube from ovary of newly emerged female; *c*, same as *b*, 23 days after emergence (January) of adult; *d*, same as *b*, 33 days after emergence (January-February) of adult; *e*, egg tube containing) mature egg ready to be fertilized. Highly magnified. (Original.)**





PROTECTING CUCURBITS FROM ATTACK BY MELON FLIES.

Figures 1 and 2 illustrate one of the methods employed by Oriental market gardeners to protect developing cucurbits from melon-fly attack. Each fruit (in this case of *Momordica* sp.) is placed immediately after it has been fertilized, within a long envelope made of newspaper. (Original.)

had evidently retreated when the outer decayed leaves were disturbed.

Kohlrabi has been reported infested by Severin[1] (45).. The writers have never found larvæ attacking this plant, and because of the frequency with which the larvæ of *Acritochaeta pulvinata* are found in decaying portions, as in cabbage, the writers believe that cabbage and kohlrabi have been erroneously recorded as host plants.

### PEPPERS.

Fullaway (44) in 1913 is responsible for the only record of peppers as a host fruit for the melon fly, although he does not state the nature of the infestation. Larvæ of *Acritochaeta pulvinata* and of the Mediterranean fruit fly are found in bell peppers. The careful examination of 1,000 bell peppers grown at Waikiki close by badly infested tomatoes and cucumbers during November, 1915, showed infestation only by the Mediterranean fruit fly. A like number of fruits gathered from the same locality during August, 1914, and placed over sand in jars produced no evidence of infestation by the melon fly.

### WILD FOOD PLANTS.

The two species of cucurbits, *Sycos* sp. and Chinese cucumber (*Momordica* sp.), are the only host fruits that can be considered wild in Hawaii. The Momordica beyond question has recently escaped cultivation. The fruits of both are readily susceptible to melon-fly attack. Fortunately *Sycos* sp. (Pl. XXI, fig. 2) is not abundant and the Momordica (Pl. XXII) is limited in its distribution although spreading fast.

The writers have found fruits of the Sycos infested on the windward side of Oahu and in the Kona district of Hawaii. The Momordica has escaped cultivation in many places in Hawaii and wherever present is found infested. On the island of Hawaii, in the Kona district, from sea level to about 1,500 feet, its vines have formed dense growths over the stone walls and bushes and have even killed out large patches of grass. Its fruits are more susceptible to attack than those of Sycos, but both host fruits, especially in Kona, furnish with their fruits ripening at all seasons a continuing supply of food upon which the melon-fly larvæ can feed, whether or not cultivated host fruits are grown in their neighborhood. From Momordica vines covering a patch of pasture land 6 feet square, 331 fruits were gathered during November, 1914, of which only 12 had not been infested.

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[1] Severin states in correspondence that he certainly reared the melon fly from kohlrabi and eggplant under field conditions.

These fruits, which were of all sizes up to 1½ inches in diameter, averaged between three and four punctures per fruit, with a maximum of 15 punctures on the more exposed fruits. From 7 feet of stone wall 442 fruits were gathered, and of these 193 were so badly affected that they had dried up without developing seeds, and only 11 were not affected. From 250 fruits placed over sand 1,586 larvæ, or an average of 6.5 larvæ per fruit, were reared.

## LIFE HISTORY AND HABITS.

### METHOD OF STUDY.

As adults die in greatest numbers within 48 to 72 hours after emergence if food is not given them, those required for future observation must be transferred to a place where they may be fed and cared for daily. In this work the writers have found glass jars 9 by 12½ inches covered with cheesecloth very convenient. Such jars will hold from 100 to 200 flies in good condition. Fruit juices of almost any sort are eagerly eaten. Water slightly sweetened with pineapple (*Ananas ananas*) sirup was used with good results but was replaced later by a mixture of water and finely divided parts of papaya (*Carica papaya*). When fed on such diluted food adults thrive best on two feedings a day, one in the morning and one late in the afternoon. The food may be applied in finely divided drops to the sides of the jar by flirting the mixture forcibly against the cheesecloth covering by means of a snapping movement of the thumb and forefinger. The adults feed greedily and soon become distended. In this condition many fall and rest upon the bottom of the jar; hence, the less food falling on this portion of the jar the fewer will be the deaths resulting from entanglement in it. Feeding by flirting mixtures through the cloth covering causes the sides of the jars to become soiled quickly and necessitates the changing of adults to clean jars every two or three days.

Eggs may be easily secured by suspending host fruits within the jars containing sexually mature adults. Breaks made in the epidermis of the host fruit with any sharp object often insure the deposition of eggs in the portion of the fruit desired. By timing the exposure of fruits with adults, eggs of definite age can be secured; and if these are immediately dissected from the fruits, arranged on a green leaf, and placed over a plug of wet cotton in a vial inverted in water the embryonic development and hatching may be observed under normal conditions of heat and moisture. In obtaining detailed data on larval development single larvæ upon hatching may be placed in small squares of ripe papaya pulp and transferred twice daily to fresh squares. Pupæ of known age can be obtained easily by placing infested host fruits over sand and sifting the sand at stated frequent intervals for the larvæ and puparia. The labor of sifting is made easier if the fruits are placed on a wire mesh which holds them away from the sand.

## THE ADULT.

### DESCRIPTION.

The adult of the melon fly is larger than related species of Bactrocera, being under normal conditions from 6 to 8 mm. in length. According to Bezzi (36) it may be distinguished from all other Indian species by the fact that it has the posterior cross-vein widely bordered with brown. The original description by Coquillett (2), which is good, is given in full in the bibliography (p. 58), together with the supplementary notes made by Bezzi (36), and to those descriptions the investigator should refer for details. In general the arrangements of the black spots upon the yellowish head, the light yellow markings upon the reddish-yellow thorax, and the brown spots upon the otherwise hyaline wings make the identification of the melon fly an easy matter. As a further aid to identification figure 1 and Plate II have been added.

### EMERGENCE.

Adults emerge during the early morning hours in warm weather, but during cooler weather more scatteringly throughout the day. In common with all Cyclorrhapha, the adult makes use of the ptilinum in breaking the walls of the puparium and in forcing its way to the surface of the soil, or in extricating itself from other confining walls. Just after emergence, before the normal colors of the body have developed and while the chitin is still flexible, the adults are able to push their way through incredibly small openings, being able so to flatten their bodies that they can make use of small cracks in soil from which they could not otherwise escape, and can extricate themselves from containing fruit boxes and many other containers not absolutely tight. Cracks of the thickness of ordinary blotting paper do not always prevent their escape just after emergence.

### LONGEVITY OF ADULT MELON FLIES.

*With food.*—The data included in Table I are the first that have been made to determine the age to which adult melon flies can live if kept well supplied with food. One female lived from February 17, 1914, to April 4, 1915, or 13 months and 15 days, a total of 431 days. One female emerging at the same time, but not included in Table I, lived until April 3, 1915. In general, the adult melon fly appears to be very hardy and far more resistant to moisture in rearing jars than is the adult of the Mediterranean fruit fly. This may be due principally to the larger and more robust build of the melon fly. The data in Table I, covering the 9½ months after the flies had reached the age of 4 months, show that the death rate is low among the older flies. Two other lots of adults of 43 (15 males and 28 females) and 44 (15 males and 29 females) individuals of the same age and similarly cared for, and upon which like data were secured, died at practically the same rate as the flies recorded in Table I.

Of any lot of adults kept in confinement for experimental purposes fully 30 per cent may be expected to die within the first 2 to 4 weeks of life, even when given the best of care and kept in jars not overcrowded. Two adults emerging on August 28, 1913, died on October 29 and November 2, respectively. Of 15 flies issuing August 26, 1913, one lived until November 27, but the others were dead by October 20. Other data might be included, but they would bring out no facts to disprove that the length of adult life is variable under like conditions. The chief interest centers about the fact that certain adults may live long periods and thus keep the pest alive during seasons when host fruits are not in condition for oviposition.

TABLE I.—*Longevity of adult melon flies emerging on Feb. 17, 1914.*[1]

| Date of observation. | Number of flies alive. | | Number of flies dead. | | Date of observation. | Number of flies alive. | | Number of flies dead. | | Number of eggs deposited on sides of jar.[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| | Male. | Female. | Male. | Female. | | Male. | Female. | Male. | Female. | |
| June 17 | 21 | 23 | | | Dec. 17 | 8 | 14 | | 1 | 12 |
| 27 | 21 | 23 | | | 22 | 8 | 14 | | | 54 |
| 29 | 20 | 23 | 1 | | 26 | 4 | 11 | 4 | 3 | 56 |
| July 7 | 20 | 23 | | | 29 | 4 | 10 | | 1 | 35 |
| 10 | 20 | 22 | | 1 | Jan. 2 | 4 | 10 | | | 21 |
| 13 | 19 | 22 | 1 | | 5 | 4 | 10 | | | 14 |
| 16 | 19 | 22 | | | 8 | 4 | 10 | | | 6 |
| Aug. 1 | 19 | 22 | | | 12 | 4 | 10 | | | 26 |
| 3 | 18 | 22 | 1 | | 15 | 4 | 9 | | 1 | 20 |
| 6 | 18 | 22 | | | 20 | 4 | 9 | | | 58 |
| 8 | 18 | 21 | | 1 | 25 | 4 | 9 | | | 62 |
| 19 | 18 | 21 | | | 29 | 4 | 9 | | | 17 |
| 22 | 17 | 20 | 1 | 1 | Feb. 1 | 3 | 9 | 1 | | 36 |
| 24 | 17 | 20 | | | 4 | 3 | 8 | | 1 | 14 |
| 27 | 16 | 20 | 1 | | 10 | 2 | 7 | 1 | 1 | |
| 29 | 16 | 20 | | | 23 | 1 | 7 | 1 | | 33 |
| Sept. 12 | 16 | 19 | | 1 | 25 | 1 | 6 | | 1 | 11 |
| 14 | 14 | 17 | 2 | 2 | 27 | 1 | 6 | | | 37 |
| Oct. 16 | 13 | 17 | 1 | | Mar. 5 | 1 | 5 | | 1 | |
| 21 | 13 | 17 | | | 11 | 1 | 3 | | 2 | |
| 27 | 13 | 16 | | 1 | 22 | 0 | 3 | 1 | | 11 |
| Nov. 7 | 12 | 16 | 1 | | 25 | | 2 | | 1 | 11 |
| 11 | 9 | 16 | 3 | | 29 | | 1 | | 1 | |
| 17 | 8 | 16 | 1 | | 31 | | 1 | | | |
| 25 | 8 | 15 | | 1 | Apr. 3 | | 1 | | | |
| Dec. 2 | 8 | 15 | | | 4 | | 0 | | 1 | |

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[1] Mortality records were not started until June 17, or not until the flies were 4 months old.

[2] No record of eggs deposited on sides of containing jars were started until December 17, or not until the flies were 10 months old. Compare data with data on daily rate of oviposition.

*Without food.*—Adult melon flies die rapidly within a few days if not given an opportunity to feed. This is shown by the records of mortality of flies placed in clean glass jars and given no food or water, but kept otherwise under conditions identical to those under which flies regularly fed are kept. No flies in the following experiments lived for more than 100 to 102 hours without food and water, or for more than 120 hours without food but with water. Flies that had been regularly fed for over 6 months did not live longer when deprived of food than those kept without food from emergence. The rate of mortality among six lots of adults was as follows:

(1) Twenty-five adults, emerging on January 3 and fed daily on papaya and water until 9 a. m., January 17, were placed in a clean jar immediately after feeding. Thereafter they were given only water three times daily. One died between 4 p. m., January 17, and 9 a. m., January 18; 1 between 2 and 3 p. m., January 19, 2 between 4 p. m., January 19, and 9 a. m., January 20; 13 between 4 p. m., January 20, and 8 a. m., January 21; 1 between 11 a. m. and 12 m., January 21; and 3 between 4 p. m., January 21, and 9 a. m., January 22.

(2) Fifteen adults, which emerged June 22, 1915, and fed until December 13, 1915, were placed at 9 a. m. of the latter date, immediately after being fed, in a clean glass jar. All were dead by 8 a. m., December 17. Three died between 1 and 4 p. m., December 14; 6 between 4 p. m., December 14, and 4 p. m., December 15; 3 between 4 p. m., December 15, and 8 a. m., December 16; 3 between 4 p. m., December 16, and 8 a. m., December 17.

(3) Thirteen adults, emerging about 8 a. m., December 26, 1915, were placed in a glass jar. These flies had no opportunity to feed after emerging. Two died between 4 p. m., December 27, and 8 a. m., December 28; 8 between 4 p. m., December 28, and 8 a. m., December 29; and 3 between 1 and 3 p. m., December 29.

(4) Sixty-six adults, emerging about 9 a. m., December 30, 1915, were placed, without having been fed, in a clean jar. Ten died between 9 p. m., December 31, and 8 a. m., January 1, 1916; 28 between 9 a. m., January 1, and 8 a. m., January 2; 3 between 3 and 6 p. m., January 2; 5 between 9 p. m., January 2, and 6 a. m., January 3; and 1 between 1 and 3 p. m., January 3.

(5) One hundred and forty-nine adults, emerging about 9 a. m., December 31, 1915, were placed, without having been fed, in a clean jar. Ten died between 3 and 6 p. m., January 1, 1916; 19 between 9 p. m., January 1, and 8 a. m., January 2; 56 between 3 and 6 p. m., January 2; 47 between 9 p. m., January 2, and 6 a. m., January 3; 11 between 1 and 3 p. m., January 3; 5 between 4 p. m., January 3, and 8 a. m., January 4; and 1 between 8 a. m. and 12 m., January 4.

(6) Sixty-eight adults, emerging about 9 a. m., December 28, 1915, were placed, without having been fed, in a clean glass jar. Two died between 4 p. m., December 29, and 8 a. m., December 30; 8 between 1 and 4 p. m., December 30; 57 between 4 p. m., December 30, and 8 a. m., December 31; and 11 between 1 and 3 p. m., December 31.

### FOOD OF ADULTS.

The food of the adult melon fly consists of plant juices, honeydew, nectar, or even the juices of dead insects. In confinement the flies may be seen occasionally feeding upon specimens which have died, although this does not appear to be a universal habit. Severin (45) has observed one adult feeding upon a dead and partly decomposed caterpillar. The observations of the writers would indicate that adults obtain the larger portion of their food from honeydew, and especially from the juices exuding from the injured portions of their hosts. Adults are found in large numbers on foliage covered with the exudations of honeydew, no matter whether it is formed by the cane leafhopper (*Perkinsiella saccharicida* Kirkaldy) on sugar cane, by the green scale (*Coccus viridis* Green) on coffee leaves and fruit, by the corn leafhopper (*Peregrinus maidis* Ashm.) on corn tassels and leaves, by the bean aphis (*Aphis gossypii* Glover) on different varieties of beans, or by the banana aphis on banana foliage and flowers. Wherever honeydew is present the melon fly is among the many insects attracted.

The adults are particularly fond of the juices exuding from the ruptures made by the female in the epidermis of the host while forming the cavity in which to deposit eggs. Cucurbits in general exude considerable juice when injured, and this is eagerly eaten by both sexes of adults. Fruits broken in the field, crushed vines, and even the decayed areas in infested fruits are attractive to adults. Although adults have seldom been observed to visit the flowers of cucurbits in search of food, they have been observed, apparently feeding, among the flowers of *Acacia farnesiana* Willd., the banana (*Musa* spp.), and sunflower (*Helianthus* sp.). On numerous occasions they have been seen drinking small droplets of moisture during the early morning or after light showers.

In the laboratory, in confining jars, the adults have been kept alive by feeding with several fruit juices, but they thrived best upon papaya pulp passed through cheesecloth and then diluted with about twice its bulk of water.

Of special interest is the attraction of the flowers of the orchid *Phalaenopsis schilleriana* Reichb. f. Mr. W. M. Giffard, of Honolulu, first observed adults feeding upon the nectar of this orchid during April, 1913. Dr. H. L. Lyon and Mr. Albert Waterhouse, also of Honolulu, have observed many adults about their greenhouses into which they had been lured by the orchid flowers. One florist feared that the adult melon fly might injure the blooms, but experiments and observation proved that they were only after the nectar.

### PROPORTION OF SEXES.

The sexes are quite evenly divided. The examination of 1,049 individuals emerging from 8 lots of fruit showed 524 to be males and 525 to be females. The proportion of sexes of each of the eight lots is as follows:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Males | 25 | 20 | 73 | 70 | 83 | 44 | 102 | [illegible] |
| Females | 24 | 37 | 65 | 60 | 70 | 45 | 123 | [illegible] |

### MATING.

So far as the writers have been able to detect, neither sex of the melon-fly adults gives off an odor.

Inasmuch as adults of the Mediterranean fruit fly show at all times during the day, particularly during the warmer months, indications of sexual activities within three or four days after emergence, and begin ovipositing soon thereafter, the writers were at loss to explain the apparent indifference to each other of the sexes of the melon fly. It was thought for a time that failure to secure evidence of sexual activity might be due to improper confinement or feeding, and a number of lots of adults were discarded before it was discovered that melon flies mate only at dusk and only after they have become somewhat older than adults of *Ceratitis capitata.*

Recent feeding experiments with the melon fly have shown that certain foods may play an exceedingly important part in the stimulation of bodily forces, sexual activity, and egg maturation. These experiments have shown that the use of fresh cucumbers, cut open and kept constantly in the jars containing the adults, would so accelerate the development of the reproductive system that copulation commenced as early as ten days after emergence from the pupal stage. Thus, in four lots of flies emerging on October 24, 27, 28, and 29, 1916, comprising a total of 1,230 adults, mating commenced with a few individuals in each lot, successively, at sunset, the tenth day after emergence, the mean average temperature being 76.4° F. and the mean relative humidity 69.1 per cent. This is a most striking condition when comparison is made with the ages at time of first mating of adults that are confined in jars of similar size, but fed on papaya and water or sugar and water. Many hundreds of adults kept in confinement during the years 1913, 1914, and 1915 in Honolulu and fed on papaya and water were never seen to mate before 20 days after emergence. Thus, out of about 200 individuals emerging on May 24, 1914, which were fed on papaya and water one pair was noted in coition for the first time on June 13, or 20 days after emergence. Among a second lot of adults, emerging on May 23 and similarly fed, no adults mated until June 16, when two pairs were seen mating. The majority of females in these lots did not mate until they were fully 25 days old. The daily mean temperature for the period from May 23 to June 16 averaged 75.5° F., while the mean relative humidity averaged 69.3 per cent. Individuals of another lot of flies emerging January 3, 1916, and fed on papaya and water showed no indications of mating until early in February. The lower average mean temperature of 71° F., and the higher mean relative humidity of 78.5 per cent of January, were responsible for the greater period required for the beginning of sexual activity.

Evidences of sexual activity begin during the warmer months only at about sunset. From sunset until darkness the sexes are in a state of intense activity. Both sexes dart rapidly about the containing jar and in their efforts to copulate produce much confusion. Pairs remain in coitu, in some instances, until daybreak. Females mate frequently and with different males.

### OVIPOSITION.

*Age when oviposition begins.*—The age at which oviposition begins has never been determined broadly until the present investigation. Information on this point is of importance, as the adult appears to be the most vulnerable point in the life cycle of this pest from the standpoint of artificial control. Severin, who first undertook to solve this problem, states (45) that "a large number of adults upon emerging were kept in breeding jars and fed on diluted molasses, fruit and vegetable juices, and water. After having been kept in captivity for 8 days 3 females were dissected, but no fully developed eggs were found in the ovaries. A daily dissection of 3 fruit flies was continued from now on, and at the end of 14 days 23 ripe eggs were counted in the two ovaries of one fly, but others did not show mature eggs in the ovaries at the end of 16 days. At the end of 17 days 31 eggs were dissected from the ovaries of another specimen. In all probability the effect of confining the insects in breeding jars plays an important part in the rate of development of the eggs." These dissections, Severin concludes, indicate that egg-laying begins 14 to 17 days after the adults emerge.

As noted under the subject of "Mating," varying types of food supplied adults in captivity may have widely varying effects upon the development of the eggs. Thus, four lots of adults emerging on October 24, 27, 28, and 29, 1916, comprising a total of 1,230 flies, which had constant access to the juice of fresh cucumbers cut open, began ovipositing in 12, 11, 11, and 11 days, respectively, each lot depositing from 17 to 29 eggs the first day. The mean average temperature during this experiment was 76.4° F. and the mean relative humidity 69.1 per cent. When fed upon papaya and water a most surprising difference results in the rapidity of egg development. The experiment was repeated many times during the years 1913, 1914, and 1915 and many hundreds of adults were used. Thus with a mean temperature averaging 75.5° F. and the mean relative humidity 69.3 per cent females did not begin ovipositing until about one month after eclosion. While fruit was placed in jars with about 1,000 adults which emerged from May 23 to 25, no attempts at oviposition were noted until June 23, when 12 punctures containing no eggs were made in a mango by females that emerged on May 24. The first eggs, 12 in number, were laid on June 25, or 32 days after eclosion. No eggs were obtained from females that emerged on May 25 until June 28, or 34 days after eclosion. This is remarkable when comparison is made with females that were fed on cucumbers and which began ovipositing when only 11 to 12 days old.

Adults emerging on January 3, 1916, during the coldest portion of the year at Honolulu, and fed on papaya and water when the mean temperature for January was 71° F. during 1916 and the mean relative humidity 78.5 per cent, did not oviposit until February 17, although they were given abundant opportunity. In this instance no eggs were deposited until the females were 44 days old.

In the case of the adults emerging January 3, 1916, and fed on papaya and water, dissections were made of the ovaries of females at frequent intervals from the time of emergence until egg laying began. The appearance of the ovarian tubes dissected from females 1, 23, 33, and 38 days after emergence is shown in Plate XXIII. At no time were the ovarian tubes found to contain a well-graduated series of eggs, as is found in many insects, or as found by Dr. Illingsworth in the ovarian tubes of the apple maggot (*Rhagoletis pomonella* Walsh) and the cherry fruit fly (*Rhagoletis fausta* O. S.)

From the observations made upon the development of the eggs of melon flies fed upon the juice of cucumbers it seems reasonable to conclude that under natural conditions egg deposition commences almost as soon as the eggs have reached maturity in the egg tubes.

Whether confinement does retard egg development has been difficult to determine, but development of eggs within the ovarian tubes of the Mediterranean fruit fly progresses so rapidly in confinement under like conditions that the writers conclude that confinement of the female melon fly in large jars, with plenty of food, does not retard development.

*Portion of plant selected.*—The female fly deposits eggs at random in various portions of the host plants, the portion selected depending largely upon the stage of growth and variety of host. In young seedlings, particularly succulent watermelon seedlings, eggs are deposited within the crown of the plant or in the petiole of the leaf. As the cucurbits develop runners the eggs may be deposited in these, usually near the growing tip or less frequently farther back in the tougher, older portions. The older vines are seldom made use of for oviposition, and of the cucurbits, the vines of the pumpkin, squash, momordicas, and cucumbers are least attractive. No oviposition has been noted in tomato or bean stalks. The female prefers to oviposit within the unfertilized, still undeveloped ovaries of all cucurbits, with the exception of the young cucumbers, which are not attacked until the fruits are from 2 to 4 inches long. Ovipositing into the male bloom of squash and pumpkin is so universal that it would appear that this portion of the plant is as attractive to the female as the unfertilized ovaries. Oviposition has never been observed to occur in the male bloom of watermelon, cantaloupe, *Momordica* spp., or the bloom of tomatoes, cucumbers, and beans. Even after pumpkins and squashes become so well developed that the melon-fly larvæ can not penetrate and cause their destruction, the female deposits batch after batch of eggs in the breaks in the epidermis and superficial wounds made by larvæ developing from previously deposited eggs.

*Process of oviposition.*—The process of oviposition may be readily seen at all seasons of the year in Hawaii. When the female has found a suitable place for oviposition the abdomen is bent at nearly right angles to the long axis of the body by drawing its tip toward the legs. Having secured a proper purchase, the ovipositor is forced into the host to depths varying to ¼ inch. The depth of the incision made by the ovipositor varies with the succulency of the host, hence the small chamber for the reception of the eggs may lie directly beneath the epidermis or fully the length of the eggs beneath it. The data included in Table II indicate that the female does not deposit more than 37 eggs at one time, although many punctures contain but one egg. The number of eggs found in any one puncture, especially where the number is large, is not indicative of the number of eggs deposited during one period of oviposition, as many females may oviposit through the same break in the epidermis, or the same female may return more than once to deposit fresh batches of eggs. This is particularly true in the case of host fruits which may offer obstacles to egg laying.

*Rate of oviposition.*—No data have ever been published on the daily rate of oviposition, except by the writers in their preliminary paper (46). The data included in Tables II, III, and IV record the rate of oviposition not only of individual females which, from the time they began ovipositing until they died, were kept well supplied with host fruits, but also of others which had been deprived of host fruits until they were over 9 months of age.

In Table II is recorded the rate of oviposition of 7 females which were given every opportunity to oviposit in preferred host fruits, tomatoes, throughout life. No fly deposited more than 37 eggs a day. Fly No. 1 deposited 14, 19, 13, 29, 16, 19, 16, 12, 17, 7, 9, 16, 7, 12, 37, 25, 24, 21, 28, 6, and 18 eggs, respectively, per day during the first three months (summer months) after depositing her first eggs. During the same period fly No. 3 deposited but 13, 9, 15, 10, 4, 19, 3, 18, 4, and 3 eggs, while fly No. 4 deposited 3, 10, 25, 6, 11, 11, 6, 11, 1, 3, 16, 10, 9, and 24 eggs. Fly No. 1 deposited in the winter months during the seventh, eighth, and ninth months of life 10, 2, 18, 14, 15, 20, 13, 9, and 3 eggs. Fly No. 4 deposited during the ninth and last month of life (winter month) but 3, 2, 3, 4, 1, 1, and 1 eggs.

The oviposition records of Table III were made by females given no opportunity to oviposit in host fruits until over 3 months old. Fly No. 1 deposited 21, 14, 4, 1, 10, 18, 3, 3, 16, 2, 8, 13, 13, 8, 10, 10, 12, 9, and 16 eggs, respectively, per day during the first 3 months (summer months) after having been given access to host fruits. Under like conditions fly No. 2 deposited 2, 17, 13, 12, 4, 7, 16, 14, 28, 8, 12, 17, 12, and 29 eggs, respectively, per day during the first 4 months.

Fly No. 1 of Table IV, which was not given access to host fruits until she was nearly 8 months old, deposited, as indicated, 21, 7, 13, 3, 18, 13, 10, and 2 eggs on different days during the ninth month (October-November) of her life. Fly No. 2 of Table IV, which was not given access to host fruits until she was nearly 9½ months old, deposited 6, 2, 7, 6, 3, 6, 1, 3, 12, 3, 3, 8, and 4 eggs on different days during the eleventh, twelfth, and thirteenth months of life, which also were the last 3 of life and colder than the average for December, January, and February at Honolulu.

The melon-fly female differs from the female of the Mediterranean fruit fly in that she deposits a larger number of eggs per day at greater intervals instead of a smaller number almost daily. Fly No. 4, Table II, very closely approached the habit of *Ceratitis capitata* by depositing a small number of eggs daily with great regularity from November 2 to the middle of the month. It will be noted that the flies whose records appear in Table IV averaged 10 and 6 eggs, respectively, for each day on which they oviposited, which compared quite favorably with the averages of 9.5, 13.6, and 13.5 of Table III and 14.9, 9.4, 6.3, 5.3, 10.3, 7.6, and 13.1 of Table II, especially when one considers the small number of flies under observation and the variation in egg-laying capacity shown by the larger number and very much younger flies of Table II, and the colder months of the year during which the eggs were deposited. Fly No. 1 of Table II, which deposited a total of 687 eggs, averaged but slightly over 3 eggs per day during the 227 days between the time when she deposited her first and last eggs.

TABLE II.—*Daily rate of oviposition of the melon flies that emerged on May 25 and were placed separately with fruit on June 25, 1914.*

| Date of observation.[1] | Number of eggs deposited. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fly No. 1. | Fly No. 2. | Fly No. 3. | Fly No. 4. | Fly No. 5. | Fly No. 6. | Fly No. 7. |
| 1914. | | | | | | | |
| July 10 | | | | | | 23 | |
| 11 | | | 13 | | 17 | | |
| 15 | 14 | | | | | 12 | |
| 17 | | | 9 | | 14 | | |
| 18 | 19 | | | | | | |
| 19 | | | | | | | 19 |
| 21 | | | | | | 6 | |
| 22 | 13 | | | | | | |
| 23 | | | | | 10 | | |
| 24 | | | | 3 | | | |
| 26 | | | | | | 23 | |
| 27 | 29 | | | | | | |
| 29 | | | | | 21 | | |
| Aug. 1 | | | | 10 | | 5 | |
| 2 | | | 15 | | | | |

[1] Dates on which none of the flies oviposited are omitted from the table.

**TABLE II.**—*Daily rate of oviposition of the melon flies that emerged on May* [illegible] *and were placed separately with fruit on June 25, 1914*—Continued.

| Date of observation. | Number of eggs deposited. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fly No. 1. | Fly No. 2. | Fly No. 3. | Fly No. 4. | Fly No. 5. | Fly No. 6. | Fly No. 7. |
| 1914. | | | | | | | |
| Aug. 4 | | 2 | | | 15 | | |
| 5 | | | | 25 | | | |
| 6 | 16 | | | | | | |
| 7 | | 6 | | | | | |
| 8 | | | | | 10 | 8 | |
| 9 | 19 | | | | 3 | | |
| 11 | | | | 6 | | 1 | |
| 12 | | | | | 2 | | |
| 13 | | | | | 10 | | |
| 14 | 16 | | | | | | [illegible] |
| 15 | | | 10 | | | | |
| 16 | | | | | | 1 | |
| 17 | | | | | 11 | 2 | [illegible] |
| 18 | | | | 11 | | | |
| 19 | 12 | | | | | 1 | |
| 23 | | | | | | 8 | |
| 24 | 17 | 12 | | | 9 | | |
| 29 | 7 | | | 11 | 5 | | |
| 30 | 9 | | | | | | |
| Sept. 2 | | | | | | 2 | |
| 3 | | 3 | | | | | |
| 4 | 16 | | | | | | |
| 5 | | | | | 7 | | |
| 6 | | | | 6 | (¹) | | |
| 8 | 7 | 13 | | | | | |
| 9 | 12 | | | | | | |
| 10 | | | | | | (²) | |
| 17 | | | | | | | [illegible] |
| 18 | | 5 | 4 | | | | |
| 19 | | | | | | | [illegible] |
| 23 | 37 | 24 | | 11 | | | |
| 25 | 25 | 10 | | 1 | | | |
| 26 | | 13 | 19 | | | | [illegible] |
| 27 | 24 | | | | | | |
| Oct. 2 | | 6 | 3 | 3 | | | [illegible] |
| 7 | 21 | (³) | 18 | 16 | | | [illegible] |
| 9 | 28 | | | 10 | | | |
| 10 | 6 | | 4 | 9 | | | |
| 12 | | | | 24 | | | [illegible] |
| 13 | 18 | | | | | | [illegible] |
| 14 | | | 3 | | | | |
| 15 | 4 | | | 19 | | | [illegible] |
| 16 | 29 | | 16 | 4 | | | [illegible] |
| 17 | | | | 16 | | | [illegible] |
| 18 | 32 | | | 5 | | | [illegible] |
| 19 | 1 | | 2 | 13 | | | [illegible] |
| 20 | 6 | | | 2 | | | [illegible] |
| 21 | 31 | | 5 | 15 | | | [illegible] |
| 23 | 6 | | 9 | 4 | | | [illegible] |
| 24 | 7 | | | 9 | | | |
| 25 | | | 8 | | | | [illegible] |
| 26 | | | | | | | [illegible] |
| 27 | 19 | | | 12 | | | |
| 28 | | | | 2 | | | [illegible] |
| 29 | 19 | | 14 | 14 | | | |
| 30 | | | | | | | (¹) |
| Nov. 2 | 2 | | 4 | 8 | | | |
| 3 | 23 | | 12 | 5 | | | |
| 4 | | | | 14 | | | |
| 5 | | | | 2 | | | |
| 6 | 10 | | | 7 | | | |
| 7 | | | | 5 | | | |
| 8 | | | | 8 | | | |
| 9 | | | 1 | 7 | | | |
| 10 | | | | 10 | | | |
| 11 | | | | 8 | | | |
| 13 | | | | 9 | | | |
| 15 | | | | 8 | | | |
| 17 | 11 | | | 2 | | | |
| 18 | | | 10 | | | | |
| 19 | 9 | | 1 | 4 | | | |
| 21 | | | | 3 | | | |

[1] Fly escaped.
[2] Died on this date; no eggs in abdomen.
[3] Died on this date.

TABLE II.—*Daily rate of oviposition of the melon flies that emerged on May 25 and were placed separately with fruit on June 25, 1914*—Continued.

| Date of observation. | Number of eggs deposited. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fly No. 1. | Fly No. 2. | Fly No. 3. | Fly No. 4. | Fly No. 5. | Fly No. 6. | Fly No. 7. |
| 1914. | | | | | | | |
| Nov. 22 | | | | 8 | | | |
| 25 | 10 | | | | | | |
| 26 | | | | 3 | | | |
| 27 | 2 | | | | | | |
| 30 | | | | 2 | | | |
| Dec. 1 | | | | 3 | | | |
| 2 | 18 | | | 4 | | | |
| 6 | 14 | | | | | | |
| 13 | | | 10 | 1 | | | |
| 14 | 15 | | | 1 | | | |
| 19 | | | | 1 | | | |
| 20 | 20 | | | | | | |
| 1915. | | | | | | | |
| Jan. 3 | | | | (1) | | | |
| 4 | | | 1 | | | | |
| 8 | 13 | | | | | | |
| 14 | 9 | | | | | | |
| 16 | | | 3 | | | | |
| 27 | 9 | | | | | | |
| Feb. 1 | | | (1) | | | | |
| 27 | 3 | | | | | | |
| Mar. 26 | (1) | | | | | | |
| Total | 687 | 94 | 152 | 261 | 134 | 91 | 302 |

[1] Died on this date.

*Number of eggs deposited by single females.*—It has been difficult to ascertain the maximum egg-laying capacity of individual females owing to the immense amount of time required in keeping the flies supplied with fresh host fruits and in making the daily searches for eggs deposited, and the disadvantages accruing through mortality. It has been shown that the rate of oviposition, as evidenced particularly by the data in Table II among young flies of the same age and kept under identical conditions, varies for no apparent reason. The total numbers of eggs deposited by the 7 females of Table II are 687, 94, 152, 261, 134, 91, and 302, respectively. Fly No. 1 of Table III, which was placed with host fruits for the first time when she was about 13 weeks old, deposited a total of 200 eggs during the remaining 100 days of life. Since Fly No. 1 of Table II deposited 687 eggs during the 10 months of life, and other females kept without access to host fruits deposited eggs during the 398 to 400 days following emergence (Table I), it would appear, as substantiated by the data collected, that under the most favorable climatic conditions in the field a total of 1,000 eggs per female is not too great a number to expect of vigorous and long-lived females.

*Oviposition in absence of host plants.*—The fact that the flies whose egg-laying capacity is recorded in Tables III and IV were not given an opportunity to oviposit in fruits until 3, 8, and 9 months after emergence does not indicate that sexual development had been completely checked during this interval, or that no eggs were deposited. Females will deposit eggs on the sides of the containing receptacles if they are not given fruit in which to oviposit. They do not seem, however, to deposit as freely as when placed with fruits. A small number of flies, still alive of those emerging from pupæ in February 17, 1914, were observed to lay, as usual, a few eggs on the sides of the containing jars. A record of the eggs deposited was made every few days, beginning with December 17, 1914, and ending April 4, when the last female died. The record of these eggs appears in Table I under the subject of longevity of adults. The dates on which the observations were made were arbitrarily chosen to conform with other laboratory work and are not necessarily those on which the eggs were actually laid. When one considers that these females had no fruit offered them throughout their life, the number of eggs laid is very interesting; thus 11 eggs were deposited between March 22 and 25, or from 398 to 400 days after the flies emerged.

*Ability to resume normal oviposition after period of scarcity of host fruits.*—The data in Tables III and IV are valuable, inasmuch as they demonstrate that the female melon fly which has been deprived of all opportunity to oviposit in fruit can begin ovipositing at the normal rate when host fruits become available. Thus the three flies whose records are included in Table III had been kept in glass jars from the date of their emergence from pupæ on February 17 until May 22, or about 13 weeks, while the two whose records appear in Table IV were not given an opportunity to oviposit in fruits until October 8 and November 26, respectively, or from about 31 weeks to about 37 weeks after emergence.

TABLE III.—*Daily rate of oviposition of melon flies that emerged on February 17 and were placed separately with fruit on May 22, 1914.*

| Date.[1] | Number of eggs deposited. | | | Date. | Number of eggs deposited. | | |
|---|---|---|---|---|---|---|---|
| | Fly No. 1. | Fly No. 2. | Fly No. 3. | | Fly No. 1. | Fly No. 2. | Fly No. |
| May 22 | 21 | | | Aug. 3 | 13 | | |
| 30 | 14 | 2 | | 4 | | | [illegible] |
| 31 | 4 | | 2 | 8 | | 8 | |
| June 6 | | 17 | | 9 | 8 | | |
| 8 | | 13 | | 10 | 10 | | [illegible] |
| 15 | | | 9 | 12 | 10 | | [illegible] |
| 16 | 1 | | | 15 | | | [illegible] |
| 17 | | 12 | | 16 | | 12 | |
| 21 | 10 | | | 17 | 12 | | |
| 23 | | 4 | | 18 | | | [illegible] |
| 28 | | | 10 | 19 | 9 | | |
| 30 | 18 | | | 22 | 16 | | |
| July 9 | | 7 | | 25 | 2 | | |
| 13 | 3 | | | 29 | | 17 | |
| 15 | | 16 | | 30 | 7 | | |
| 16 | 3 | | | Sept. 3 | | | [illegible] |
| 19 | 16 | | | 6 | ([2]) | | |
| 21 | 2 | | | 17 | | 12 | |
| 24 | | 14 | | 23 | | 29 | |
| 26 | | | 17 | 24 | | ([3]) | |
| 27 | 8 | 28 | 13 | | | | |
| 30 | | | 4 | Total | 200 | 191 | [illegible] |
| 31 | 13 | | | | | | |

[1] Dates on which none of the flies oviposited are omitted from the table.
[2] Died on this date; no eggs in abdomen.
[3] Adult lost.

**TABLE IV.**—*Daily rate of oviposition of two melon flies that emerged on February 17, 1914, and were placed separately with fruit on October 8 and November 26, respectively.*

| Fly No. 1, placed with fruit Oct. 8, 1914. | | | | Fly No. 2, placed with fruit Nov. 26, 1914. | | | |
|---|---|---|---|---|---|---|---|
| Date of oviposition.[1] | Number of eggs deposited. | Date of oviposition. | Number of eggs deposited. | Date of oviposition.[1] | Number of eggs deposited. | Date of of oviposition. | Number of eggs deposited. |
| Oct. 8 | 5 | Nov. 4 | 18 | Nov. 27 | 14 | Jan. 20 | 6 |
| 10 | 12 | 9 | 13 | 30 | 4 | 26 | 1 |
| 14 | 12 | 13 | 10 | Dec. 1 | 8 | Feb. 9 | 3 |
| 17 | 21 | 15 | 2 | 6 | 8 | 16 | 12 |
| 20 | 7 | 19 | 4 | 13 | 9 | 22 | 3 |
| 23 | 13 | 27 | ([2]) | 17 | 6 | 25 | 3 |
| Nov. 2 | 3 | | | 18 | 2 | Mar. 3 | 8 |
| | | | | 21 | 7 | 12 | 4 |
| | | | | 23 | 6 | 29 | ([2]) |
| | | | | 27 | 3 | | |

[1] Dates on which no eggs were laid are omitted from this table.
[2] Died on this date.

*Activity in feeding and oviposition.*—Like numerous insects in semitropical climates, the adult melon fly rests during the heat of the day in the warmest months. During this part of the day adults may be found resting on the underside of any vegetation offering sufficient protection. During the cooler morning and afternoon hours they may be found flying about their hosts or other vegetation offering food. As cooler weather approaches and during the winter months adults are found feeding and ovipositing at all times of the day, or only during the noon hours if the mornings and evenings are cooler than usual.

### MIGRATION OF ADULTS.

Observation indicates that the adult melon fly is a very much stronger flier than the adults of the Mediterranean fruit fly. Its host plants are grown so generally throughout littoral Hawaii that it is difficult to offer conclusive data on distances covered by adults. Examination has shown that adults do not remain upon their host plants exclusively, but that they may congregate in large numbers upon the foliage of any densely growing plant, bush, or tree, either close to or at considerable distance from known host plants. They are able to rove for a number of months where no host plants are available for oviposition, and if, as the longevity of certain individuals in the laboratory would indicate, hardy specimens can subsist for over a year without host plants for oviposition, this radius of migration must be considerable. It is certain that no hosts can be planted in the Hawaiian Islands, no matter how isolated, without very soon being attacked.

Adults do not appear to travel in swarms. It is seldom that one sees more than a single individual at a time feeding upon honeydew at any distance from the host plants. In the laboratory, however, the adults often gather in small colonies upon the ceiling.

## THE EGG.

### DESCRIPTION.

The egg (fig. 2) is pure white, about 2 mm. long, elongate elliptical, nearly flat on the ventral surface, more convex on the dorsal. Eggs are often somewhat curved.

### DURATION.

The duration of the egg stage of the melon fly is very short. During the warm summer weather of August, 1914, when during the developmental periods the average mean temperature of Honolulu averaged 79.5° F. and the average range in temperature was only 8.3°, 267 eggs hatched in from 26 to 35 hours after deposition. Of these eggs, which were deposited during a period of 1 hour, as shown by the data in Table V, 149, or slightly over 56.6 per cent, hatched within from 26 to 28 hours after deposition. When the average mean temperature for the incubation period averaged 75.6° F. and the daily range in temperature about 10.4°, 84 eggs deposited between 3.15 and 3.30 p. m. on May 19 hatched between 10 p. m., May 20, and 2 a. m. May 21, or within from 31 to 38 hours after deposition. At a mean temperature of about 75° F. 96 eggs hatched within from 33 to 38 hours after deposition. At the still cooler average mean temperature of 73.6° F. 88 eggs hatched between from 40 to 50 hours after deposition.

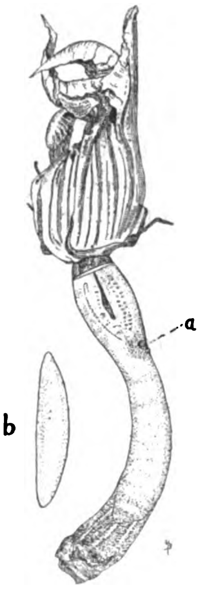

FIG. 2.—The melon fly: *a*, Eggs deposited in cavity in young pumpkin flower; *b*, single egg, enlarged. (Original.)

While the data included in Table V give information regarding the duration of the egg stage in Honolulu or littoral Hawaii in general from April to November, other data show that during January to March embryonic development may require at least 3 to 4 days when the mean temperatures drop to about 69° F. At higher altitudes this period may be appreciably prolonged, due to still lower temperatures, although it is unlikely that at any place where the melon fly is found in Hawaii the duration of the egg stage is more than 6 days. Host fruits containing eggs deposited under normal Honolulu conditions between 10 a. m. and 3 p. m., December 1, were placed, 30 minutes after deposition, in a large refrigerator and held at a temperature varying between 56° F. and 62° F. Examinations made daily by H. F. Willard show that after 4 days 38 out of 174 eggs had hatched at this temperature, while of the 138 still unhatched 103 and 10, respectively, hatched after removal to normal temperature on the fifth and sixth days. After 6 days, 44 out of 64 eggs were found hatched in another lot of fruits examined, and of the 20 eggs removed to normal temperatures but 1 hatched on the seventh day after deposition. Examinations of fruit made after the sixth day prove all eggs either to have hatched or died.

In cold-storage experiments the egg stage was prolonged to at least 12 days. Thirty-four eggs out of 107 in situ in pumpkins gathered in the field May 11, 1914, and held in storage at 49° to 52° F. until May 21, or for 10 days, hatched on May 22, or at least 11 days after deposition. During summer temperatures the duration of the egg stage may be likewise prolonged to as much as 10 days by subjecting the host fruits containing the eggs to temperatures ranging from 35 to 40° F. Table VIII contains data on the effect of cold storage temperatures upon egg mortality.

TABLE V.—*Duration of the egg stage of the melon fly at Honolulu.*

| Number of eggs under observation. | Eggs deposited. | | Eggs hatched. | | Average mean temperature for period. |
|---|---|---|---|---|---|
| | Day. | Period. | Day. | Period. | |
| | | | | | °F. |
| 17 | Aug. 20 | 10.30 to 11.30 a. m | Aug. 21 | 1 to 2 p. m | 79.5 |
| 75 | ...do | ...do | ...do | 2 to 2.15 p. m | 79.5 |
| 45 | ...do | ...do | ...do | 2.30 to 2.45 p. m | 79.5 |
| 12 | ...do | ...do | ...do | 2.45 to 3 p. m | 79.5 |
| 23 | ...do | ...do | ...do | 3 to 3.15 p. m | 79.5 |
| 9 | ...do | ...do | ...do | 3.15 to 3.30 p. m | 79.5 |
| 6 | ...do | ...do | ...do | 3.30 to 3.45 p. m | 79.5 |
| 20 | ...do | ...do | ...do | 3.45 to 4 p. m | 79.5 |
| 9 | ...do | ...do | ...do | 4 to 4.30 p. m | 79.5 |
| 37 | ...do | ...do | ...do | 4.30 to 6 p. m | 79.5 |
| 7 | ...do | ...do | ...do | 6 to 8 p. m | 79.5 |
| 5 | ...do | ...do | ...do | 8 to 9 p. m | 79.5 |
| 2 | ...do | ...do | ...do | 9 to 10 p. m | 79.5 |
| 84 | May 19 | 3.15 to 3.30 p. m | May 20 | 10 p. m. to 2 a. m | 75.6 |
| 94 | May 14 | 4 to 6 p. m | May 16 | 3 to 5.30 a. m | 75.0 |
| 13 | May 13 | 10 a. m. to 1 p. m | May 14 | About 9 p. m | 75.5 |
| 62 | ...do | ...do | ...do | 10 p. m. to 3 a. m | 75.5 |
| 77 | May 11 | 11.30 a. m. to 2 p. m | May 13 | 3 to 6 a. m | 73.6 |
| 11 | ...do | ...do | ...do | 6 to 9.30 a. m | 73.6 |

### HATCHING.

Several hours before hatching the dark-brown head-hooks of the larva can be seen working backward and forward in a probable attempt on the part of the larva to break its way through the egg membranes. The head lies just back of the pointed anterior end of the egg and the larva ultimately breaks through the inner membranes and shell at this end and crawls out through the opening thus made. As the larva pushes its way out, the rupture of the eggshell extends farther and farther back for a distance of from one-half to three-quarters of the length of the egg. The pointed tip of the egg remains uninjured. The eggshell completely collapses as soon as the larva has entirely withdrawn.

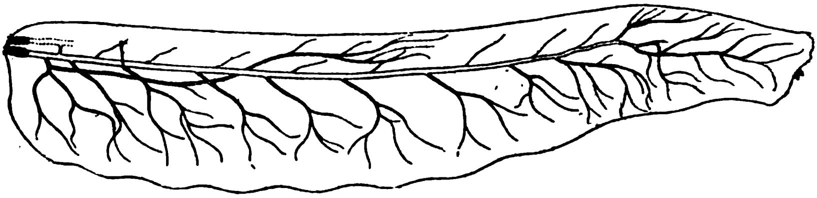

FIG. 3.—The melon fly: Newly hatched larva, showing absence of anterior spiracles and main tracheal system. Enlarged. (Original.)

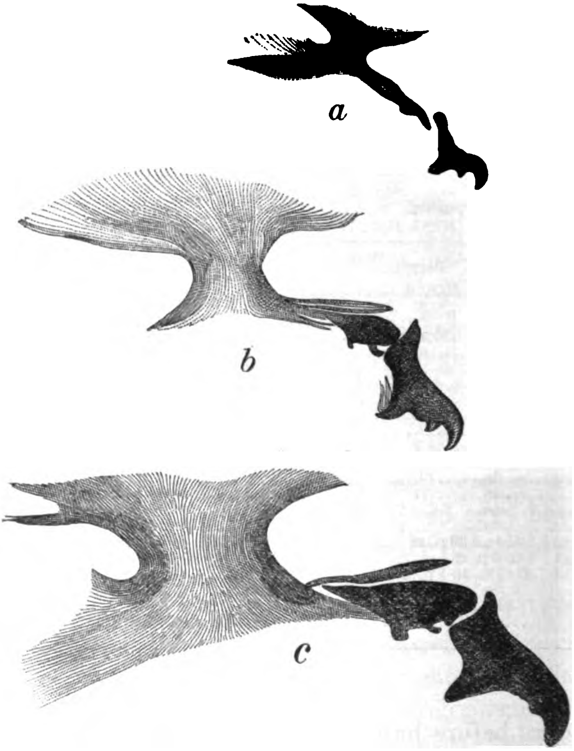

FIG. 4.—The melon fly; Mandibles or mouth hooks of larva. *a*, First instar; *b*, second instar; *c*, third instar. Enlarged. (Original.)

## THE LARVA.

### DESCRIPTION.

The larva in all instars is pure glistening white, except as appearances are altered by the color of the various host fruits within the alimentary canal. The larva passes through three instars, which are easily distinguished from each other by differences in structure as well as in size. Unless otherwise noted the Newport or hidden segment is not counted in numbering the segments.

*First larval instar* (fig. 3).—Length about 2 mm. Mouth hooks small, about 0.45 mm. long and shaped as illustrated in figure 4, *a*. Anterior spiracles found in succeeding instars are lacking. Posterior spiracles minute, being about 0.046 mm. across at the widest point. Stigmal plates approximate, each with two instead of three slits, as shown in figure 5. The fine bristles arranged in three groups about the stigmal plates are somewhat longer than the width of the tracheal trunks at their termination.

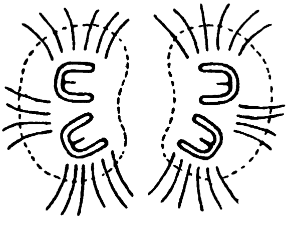

FIG. 5.—The melon fly: Posterior spiracles of first-instar larva. Enlarged. (Original.)

*Second larval instar.*—Length about 5.1 mm. The second-instar larva is sufficiently large to be readily distinguished by its size from the first-instar larva but not from undersized third-instar larvæ. It differs principally from the third-instar larva by the shape of the anterior spiracles (fig. 6, *b*), which are terminated in about 18 to 20 lobes arranged in two groups as the result of a depression in the center of the distal margin of the spiracle. Spiracles about 0.10 mm. wide at the widest point. The posterior spiracles (fig. 7) less heavily chitinized than in the third instar; stigmal plates approximate, each with three slits which are proportionately shorter than those of the third instar. The bristles about the margins of the stigmal plates arranged in four sets instead of three as in the first instar and relatively shorter and finer. Mouth hooks (fig. 4, *b*) about 0.47 mm. long.

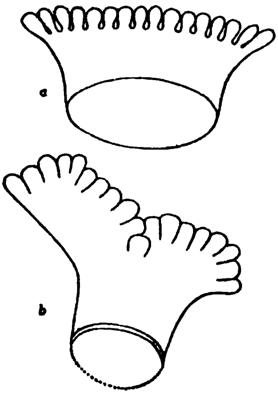

FIG. 6.—The melon fly: *a*, Anterior spiracle of third-instar larva; *b*, anterior spiracle of second-instar larva. Enlarged. (Original.)

*Third larval instar* (fig. 8).—Length about 10 mm. Head slightly bilobed, at least with two prominent thick fleshy protuberances. Each protuberance bears two pairs of microscopic papillæ, both on the distal portion, but one, the more dorsal, more antennalike in its formation, though without a terminal style or bristle; the more ventral pair but little elevated from the surrounding portions of the body, yet made quite evident by several concentric rings. Mandibles or mouth hooks very distinct, black, about 0.84 mm. long, as illustrated in figure 4, *c*. Mandibles protrude from two openings, one on each side and just anterior to the mouth opening. Between and just anterior to the mandibular openings is a slight protuberance. Labrum distinct, more or less circular, though appearing variously in different alcoholic specimens; lobes about orifice about 20 in number. Anterior spiracles on lateral margins of second segment fan shaped, with distal margin straight or

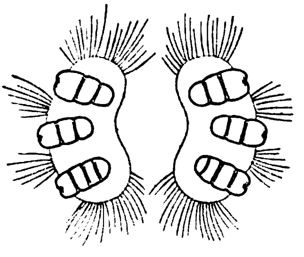

FIG. 7.—The melon fly: Posterior spiracles of second-instar larva. Enlarged. (Original.)

**but slightly rounded, bearing 18 or 20 lobes, as illustrated in figure 6, *a*. Posterior stigmal plates very evident, not appreciably elevated or depressed, approximate, each with three well-chitinized slits pointing toward those of the opposite plate as illustrated in figure 9. Slits proportionately longer and narrower than in either of the other instars. The fine bristles about margin of stigmal plate arranged in four sets, relatively finer and shorter than in the second instar. Anal opening on venter of last segment, with a rounded protuberance on either lateral side, the entire area including these protuberances elevated to form a distinct tubercle armed about its base by a concentric area of minute spinules. Body of larva glabrous, except for areas of microscopic spinules arranged as follows: Band on Newport's segment covering the anterior two-thirds of the dorsum but widening ventrally to cover the venter; narrower bands extending about the anterior margin both dorsally and ventrally of the second, third, and fourth segments; fusiform bands composed of broken rows upon the venter only of segments 5 to 12. There are no lateral spinulose areas on segments 5 to 12.**

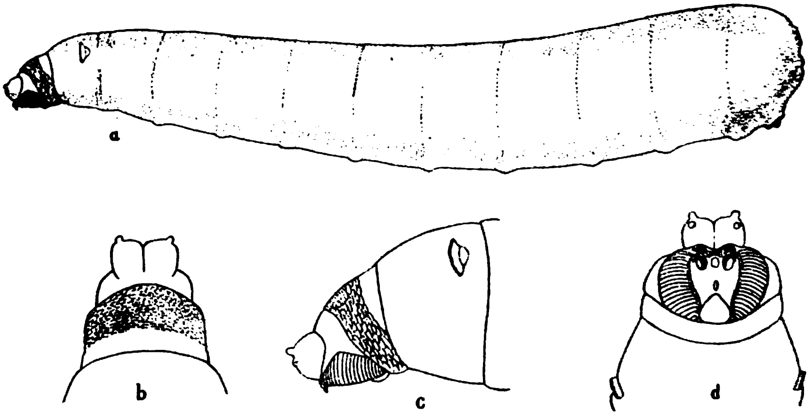

FIG. 8.—The melon fly: Third-instar larva. *a*, Lateral view of entire body; *b*, dorsal view of anterior end; *c*, *d*, lateral and ventral views of same. Enlarged. (Original.)

### DURATION OF LARVAL INSTARS.

The larva of the melon fly passes through three instars before becoming full grown. The number of hours passed in each instar has been obtained for the first 12 larvæ recorded in Table VI. These larvæ were transferred daily to fresh pieces of ripe papaya pulp, and were therefore given the best combination of food and temperature for rapid development known to the writers. The majority of these 12 larvæ passed about 1 day in each of the first two instars and about 2½ days in the third instar. An examination of the number of hours for each instar recorded in Table VI shows that variation may occur at times when no apparent cause can be assigned and that a larger number of hours passed in one instar may be followed by fewer hours than usual in the succeeding instar. As shown by the data in Table VI, larval development may be completed in as few as 4 days, or as many as 17 days, even during the hottest Hawaiian summer weather, when the average daily mean temperatures for the developmental period range between 78.2° and 79.3° F.

Both temperature and the nature of the host fruit affect larval development. Thus while 1 larva reached maturity and pupated in 4 days in fresh ripe papaya at 78.2° F., 2 larvæ required 10 and 13 days, respectively, to reach maturity in a ripe Bartlett pear at about 79° F. The larvæ developing in cantaloupes Nos. 1 and 2, recorded in Table VI, hatched from eggs deposited during a period of 1½ hours while the fruits were confined in a jar with adult melon flies, yet the larval period in one fruit ranged from 7 to 17 days.

Larval life may be extended through the medium of natural barriers to the exit of full-grown larvæ, within favored host fruits, which prevent ready access to the soil, since in small partially dried pumpkins, the interior of which is honeycombed by larval channels, the epidermis has become too toughened to permit free larval exit except at one or two places, and larval life thus may be appreciably prolonged. In very moist fruits, such as the ripe tomato, no such barrier to emergence is offered. While larvæ feed best in partial decay resulting from their own feeding, decays due to the work of bacteria or fungi, especially when they become acid, are detrimental to larval growth. These varying factors, which influence either the development of the larva or the time when it succeeds in forming its puparium, make data unaccompanied by notes on temperature and the condition of the host fruit of less value.

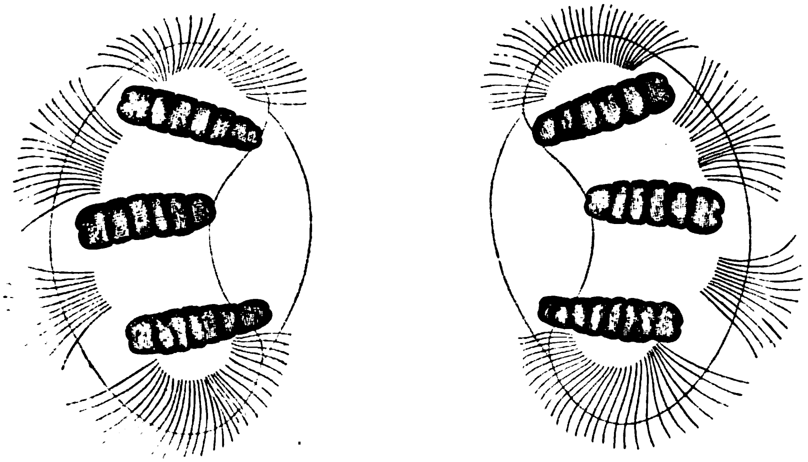

FIG. 9.—The melon fly: Posterior spiracles of third-instar larva. Enlarged. (Original.)

Cantaloupes Nos. 1 and 2, the Bartlett pear, and the cucumber, recorded as hosts in Table VI, were sufficiently ripe for table purposes when exposed for oviposition. Larvæ placed in sound green but well-grown tomatoes matured in from 4 to 7 days; 5, 14, 9, and 2 developing in 4, 5, 6, and 7 days respectively, at an average mean temperature of 78.5° to 79.1° F. Under the same temperature conditions 4 and 5 larvæ required 4 and 5 days, respectively, for development in a ripe tomato.

Lower temperatures than any experienced in Hawaii prolong larval life, although to what extent it has been impossible to determine under out-of-door conditions, because host fruits of this pest decay too rapidly. Eleven out of 23 larvæ that were fully grown when gathered in the field in pumpkins, on May 11, 1913, and placed in a refrigerator kept at 49° to 52° F., were alive when examined on June 3, or 23 days afterward, thus increasing the larval stage to at least 28 to 30 days. At this same temperature, which is sufficiently low to check development, 20 out of 62 first-instar larvæ were alive after 17 days in the refrigerator. These 20 larvæ whose development had been prolonged from about 12 hours to 17 days by the lower temperature to which they had been subjected, after removal to normal temperature of the laboratory continued their development at the same rate and emerged as adults precisely as normal individuals whose development had not been artificially arrested.

TABLE VI.—*Duration of the larval stage of the melon fly at Honolulu.*

| Number of specimens under observation. | Approximate period of development. | Host fruit. | Number of hours in— Instar 1. | Instar 2. | Instar 3. | Period in larval stage. | | Average mean temperature for period of development. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | *Days.* | *Hrs.* | *°F.* |
| 1 | Sept. 18 to 22 | Ripe papaya | 24 | 36 | 36 | 4 | .. | 78.2 |
| 1 | Sept. 25 to 29 | ....do | 24 | 24 | 50 | 4 | 2 | 79 |
| 1 | ....do | ....do | 24 | 25 | 54 | 4 | 7 | 79 |
| 1 | ....do | ....do | 25 | 25 | 51 | 4 | 5 | 79 |
| 1 | Sept. 25 to 30 | ....do | 27 | 25 | 60 | 4 | 16 | 79 |
| 1 | ....do | ....do | 26 | 40 | 52 | 4 | 22 | 79 |
| 1 | Sept. 27 to Oct. 4 | ....do | 24 | 24 | 60 | 4 | 12 | 78.1 |
| 1 | ....do | ....do | 23 | 23.5 | 60 | 4 | 10 | 78.2 |
| 1 | ....do | ....do | 23.5 | 22 | 60 | 4 | 10 | 78.1 |
| 1 | ....do | ....do | 23.5 | 23.5 | 60 | 4 | 11 | 78.1 |
| 1 | ....do | ....do | 22.5 | 23 | 60 | 4 | 11 | 78.1 |
| 1 | ....do | ....do | 25.1 | 36 | 60 | 5 | 1 | 78.2 |
| 1 | Aug. 21 to 31 | Bartlett pear | | | | 10 | .. | 79 |
| 1 | Aug. 21 to Sept. 2 | ....do | | | | 13 | .. | 78.2 |
| 28 | Aug. 21 to 27 | Cucumber | | | | 6 | .. | 79 |
| 38 | Aug. 21 to 28 | ....do | | | | 7 | .. | 78.8 |
| 4 | Aug. 21 to 29 | ....do | | | | 8 | .. | 78.8 |
| 61 | Aug. 21 to 28 | Ripe cantaloupe No. 1. | | | | 7 | .. | 78.8 |
| 98 | Aug. 21 to 29 | ....do | | | | 8 | .. | 78.8 |
| 70 | Aug. 21 to 30 | ....do | | | | 9 | .. | 78.9 |
| 18 | Aug. 21 to 31 | ....do | | | | 10 | .. | 79 |
| 8 | Aug. 21 to Sept. 1 | ....do | | | | 11 | .. | 79 |
| 2 | Aug. 31 to Sept. 2 | ....do | | | | 12 | .. | 79 |
| 3 | Aug. 21 to Sept. 3 | ....do | | | | 13 | .. | 78.2 |
| 1 | Aug. 21 to Sept. 7 | ....do | | | | 17 | .. | 78.3 |
| 12 | Aug. 21 to 26 | Ripe cantaloupe No. 2. | | | | 5 | .. | 78.1 |
| 55 | Aug. 21 to 27 | ....do | | | | 6 | .. | 78 |
| 42 | Aug. 21 to 28 | ....do | | | | 7 | .. | 78.8 |
| 5 | Aug. 21 to 29 | ....do | | | | 8 | .. | 78.5 |
| 1 | Aug. 21 to 30 | ....do | | | | 9 | .. | 78.9 |

### HABITS.

The larvæ immediately upon hatching within the egg cavity or puncture begin to feed upon the surrounding tissues of the host. In one instance only were they observed to desert the host through the punctured epidermis. In this instance the eggs from which they hatched had been deposited under forced laboratory conditions in a firm-textured apple, which is not ordinarily a host fruit. The larvæ on hatching deserted this fruit only to die on the exterior a short distance from the point of emergence.

Ordinarily the young larvæ begin immediately to burrow into the pulp of the host, and in the case of many fruits they burrow at once to the center, where they feed until well grown. When the fruits are of a watery texture, or of a very firm texture, the larvæ prefer or are forced to feed near the epidermis. In decayed spots in tomatoes or cucumbers and like fruits, which have become filled with rain water, the larvæ come to the surface for varying intervals and remain in rather dense formation, each larva perpendicular to the moisture level, with its posterior spiracles protruding. In this position the mass of larvæ remains very quiet unless disturbed. All larvæ are forced to come to the surface for air unless their tunnels are formed within a host sufficiently free from excess moisture to permit air to penetrate freely the larval channels. When hatching from eggs deposited in open wounds in well-developed pumpkins or squashes, the larvæ find it impossible to penetrate to the interior, but are able to make full development in the outer portion. (Pl. XX.)

When the larvæ have emerged from one host fruit they do not enter another except when numerous infested fruits are present in a single container, and when all are more or less decayed. The writers have not observed larvæ, having emerged from their host, burrow into sound fruits close by. Larvæ, however, have been observed to burrow into the decayed areas in other fruit touching the original host fruit, and, being found there, have been recorded as attacking that fruit, whereas their presence is accidental.

The larva of the melon fly, in common with that of the Mediterranean fruit fly, has a peculiar habit of jumping after it has left the host. Larvæ in the first two instars are unable to spring if taken from the host. The mature larva arches its body so that it is able with its mouth hooks to obtain a leverage on the posterior end of the body. This done, with a sudden muscular relaxation it is able to spring from a few to as many as 8 or 9 inches into the air or sideways. The larvæ continue to jump after leaving the host until they find a suitable place for pupation. They are not able to jump constantly in any given direction, hence they seldom get far from the point of emergence. Larvæ have been observed to travel 15 feet on concrete floors, but in the field, under usual conditions, they enter the soil to pupate directly beneath the host fruit and do not exercise to any extent this power of locomotion. When the soil is very hard the larvæ pupate beneath any object, or even upon a bare surface, as the floor of a room. On hard moist soils larvæ usually pupate upon or just beneath the surface. In the more porous soils pupation occurs at various depths, but rarely deeper than from 1 to 1½ inches. It is seldom that larvæ are unable to find their way out of their host, but when they can not they sometimes pupate within the host. Larvæ have been known to pupate in bean pods where they are imprisoned by the drying out of the pod. Pupation is apt to occur in any of the more firmly textured host fruits.

### PREPUPAL PERIOD.

The writers have chosen to look upon the pupal stage as beginning with the formation of the puparium and to refer to the duration of the pupal stage as that period between the formation of the puparium and the emergence of the adult. During the warmer seasons the contraction of the larvæ to form the puparium begins very soon after the larva emerges from the host fruit, and is completed within an hour. Larvæ forced to leave fruit prematurely may remain active for as long as two days under certain conditions, but invariably die without forming a puparium if the puparium is not formed for so long a time after emergence. Fifteen puparia formed between 11 a. m. and 1 p. m., February 3, were dissected one day later, but there was no indication of a true pupa within; no organization of internal structures could be seen except a pulsating heart. On February 5, however, or two days after the formation of the puparium, the examination of 15 puparia showed the true pupa, which was well formed and free within the puparium case. The average mean temperature during this 2-day period was 72° F., with a daily average of from 66° to 78° F. The relative mean humidity ranged between 75 and 78 per cent.

### THE PUPA.

#### DESCRIPTION.

*Puparium* (fig. 10).—Length about 5 to 6 mm. Elliptical, varying in color from dark testaceous to dull white, according to host. Being composed of the larval skin, it is natural that the markings of the larva should be found on the puparium. The puparium appears to consist of 12 segments, although when treated with potash the first is found to be composed of the first and second larval segments. When viewed from above the anterior spiracles are situated upon the outer anterior angles, and the posterior spiracles upon the central region of the posterior margin (fig. 10, *a*). When viewed from below (fig. 10, *b*) the anal opening of the larva appears as a rounded black spot on the twelfth segment, and the mouth opening as a depression in the central portion of the first segment. The broken spinulose bands upon the ventral surface of the larva appear upon segments 6 to 11 of the venter of the puparium as two narrow bands not encroaching upon the lateral sides. Between the posterior spiracles and the anal opening is a distinct transverse blackish line (fig. 10, *c*).

### DURATION OF PUPAL STAGE.

During the warmest summer weather at Honolulu, when the daily mean temperatures average between 78.7° and 79.4° F. and

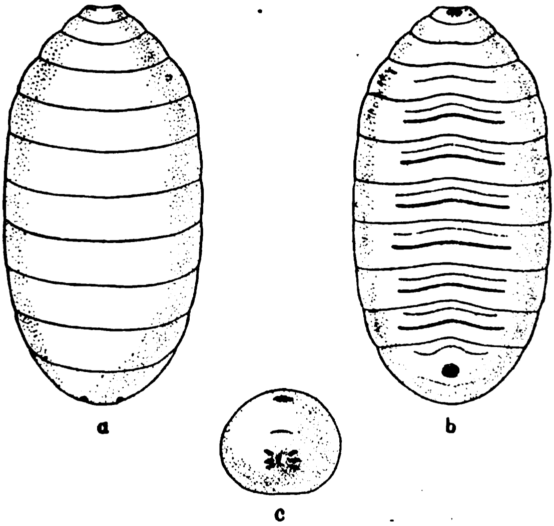

FIG. 10.—The melon fly: Puparium. *a*, Dorsal view; *b*, ventral view; *c*, view showing the posterior spiracles, oval depression, and dark line marking on posterior portion. Enlarged. (Original.)

the relative mean humidity between 64 and 70.2 per cent, by far the largest number of pupæ require 9 days for development. Of 896 pupæ, as shown by the data in Table VII, 67, 743, 85, and 1 yielded adults 8, 9, 10, and 11 days, respectively, after the formation of the puparium. During the cooler months of February, when the average mean temperature was 71.6° F. and the average mean relative humidity was 74.3 per cent, 83 and 420 pupæ required 12 and 13 days, respectively, to produce adults. From 1,037 pupæ not recorded in Table VII, 6, 125, 881, and 25 adults emerged within 7, 8, 9, and 10 days, respectively, after the formation of the puparia, when the average mean temperature ranged from 78.7° to 79.4° F.

During the winter months in the Kona district of Hawaii, where the lowest mean temperatures at Kealakekua were about 68° F., with a daily temperature ranging between 58° and 78° F., the duration of the pupal stage is considerably lengthened. Thus 7, 6, and 1 pupæ yielded adults 20, 21, and 22 days, respectively, after the formation of the puparium. From 175 puparia formed between the 1st and 3d of February, 2, 7, 151, 12, and 3 adults emerged on February 20, 21, 22, 23, and 24, respectively. At Kaawaloa, a hot sheltered spot at sea level, but within 2 miles of the station at Kealakekua, where the temperature ranged from 63° to 89° F., 126 pupæ formed on February 23 produced 5, 107, and 2 adults on March 5, 6, and 7, respectively, or in from 10 to 12 days after the formation of the puparium.

It was found by carrying pupæ to higher altitudes than those at which the host fruits of the melon fly occur in Hawaii that the duration of the pupal stage might be considerably lengthened. Thus 143 puparia just formed at Kealakekua on January 26, 1915, were taken the same day to Puulehua at about 5,000 feet elevation, where the average mean temperature from January 14 to March 19 was about 51.6° F. and where the daily range in temperature showed a variation from a minimum of 31° F. to a maximum of 72° F. From these pupæ, removed to Kealakekua on March 25, 3 adults emerged on March 26. Therefore at this temperature the duration of the pupal stage may be at least 59 days.

One hundred and twenty-four pupæ formed between February 19 and 21, 1915, and 76 pupæ formed on February 22 and 23 at Kealakekua were taken on February 24 to the summit of Hualalai, 8,275 feet elevation, where the average mean temperature during February and March was about 46.3° F. and the daily range from a minimum of 27° F. to a maximum of 73° F. These pupæ were removed to Kealakekua on March 26 and on March 31, 6 and 1 adult flies, respectively, emerged. For these 7 pupæ the duration of the pupal stage extended from 36 to 40 days.

It is the opinion of the writers that had it been possible to continue experimental work at Puulehua and on Hualalai, the duration of the pupal stage might have been still further extended, but not by very many days.

**Table VII.**—*Duration of the pupal stage of the melon fly at Honolulu.*

| Date of pupation. | Date of emergence. | Number of adults emerging. | Number of days in pupal stage. | Average mean temperature. | Average mean relative humidity |
|---|---|---|---|---|---|
| | | | | °F. | *Per cent.* |
| Aug. 14, a. m | Aug. 22, a. m | 5 | 8 | 78.7 | 72.5 |
| Do | Aug. 23, a. m | 25 | 9 | 78.9 | 71.6 |
| Do | Aug. 25, a. m | 1 | 11 | 78.9 | 70.8 |
| Aug. 17, a. m | do | 60 | 8 | 79.3 | 69.4 |
| Do | Aug. 25, p. m | 1 | 8.5 | 79.3 | 68.7 |
| Do | Aug. 26, a. m | 27 | 9 | 79.2 | 68.7 |
| Aug. 18, a. m | Aug. 25, a. m | 1 | 7 | 79.3 | 67.8 |
| Do | Aug. 26, a. m | 17 | 8 | 79.4 | 67.2 |
| Do | Aug. 27, a. m | 25 | 9 | 79.4 | 66.6 |
| Sept. 17, a. m | Sept. 26, a. m | 26 | 9 | 79.2 | 72.1 |
| Do | Sept. 27, a. m | 37 | 10 | 79.2 | 70.8 |
| Sept. 20, a. m | Sept. 29, a. m | 355 | 9 | 79.4 | 69.4 |
| Do | Sept. 30, a. m | 33 | 10 | 79.3 | 69 |
| Sept. 19, a. m | Sept. 28, a. m | 300 | 9 | 79.4 | 70.1 |
| Do | Sept. 29, a. m | 15 | 10 | 79.3 | 69.5 |
| Feb. 3, a. m | Feb. 15, a. m | 45 | 12 | 71.6 | 74 |
| Do | Feb. 16, a. m | 192 | 13 | 71.6 | 74.2 |
| Feb. 4, a. m | do | 38 | 12 | 71.6 | 74 |
| Do | Feb. 17, a. m | 228 | 13 | 71.6 | 74.2 |

## LENGTH OF LIFE CYCLE.

During the warmest Hawaiian weather, when the mean temperature averages about 79.5° F., the egg, larval, and pupal stages may be passed in as few as 12 or as many as 28½ days, according to the individual and its host. The complete life cycle is subject to great variation, according to the longevity of the adult. As one adult has been kept alive for 431 days it is evident that the complete life cycle from the deposition of egg to the death of the adult may be 443 to 459 days when the immature stages are passed during the warmer portion of the year. At an average mean temperature of about 68° F., which is the coolest mean temperature found by the writers in Hawaii, where host fruits are available for the fly and for observation, the egg, larval, and pupal stages are passed in from 40 to 45 days. It is difficult to state just what variation there may be in the length of the life cycle in still cooler climates, but it is capable of being rather great in the opinion of the writers. The pupal stage in Hawaii has been lengthened from 6 days at a mean of 79° F. to 59 days at a mean out-of-door temperature of about 5.6° F. In like manner the egg stage has been lengthened from 26 hours at 79° F. to 11 days at 49° to 52° F. in storage, the third larval stage from two days at 79° F. to at least 23 days at 56° to 62° F., and the first larval stage from 20 hours at 79° F. to 27 days at 56° to 62° F. The writers believe that with certain combinations of host fruits and temperatures the immature stage may require 3½ to 4 months, or a sufficiently long time to carry the pest over any cool period likely to be experienced by the melon fly in any habitat where it can establish itself.

## SEASONAL HISTORY.

In littoral Hawaii there may be from 8 to 10 generations of the melon fly a year when one considers the length of a generation as extending from the time the eggs are laid until the female of the next generation begins to deposit eggs. As the females are capable of living many months and of depositing eggs at frequent intervals throughout life, the generations so overlap each other that adults present in the field at any one time may belong to generations started in any month of the year. It is possible for females ovipositing on January 1 to be still alive and ovipositing the following January along with the progeny of the tenth generation of her descendents.

In the Hawaiian Islands, where the climatic conditions permit breeding throughout the year, adults of the melon fly are abundant at all seasons in the littoral regions, where, for the most part, host plants are grown. There is no evidence of seasonal broods or generations of adults. That the cooler weather of the winter months does lengthen the duration of the immature stages has already been proved by data. This slowing down of development naturally results in the emergence of fewer adults, and in forcing these to feed for a greater period of time before becoming sufficiently developed to oviposit. Unfortunately the length of adult life and the capacity of the females for continued egg laying makes it difficult for market gardeners to benefit to any marked extent from the effects of cool weather upon development if they allow their fruits to remain unprotected. The fewer adults, coupled with the shorter hours during the day when they are sufficiently active to oviposit, does result in greater success in saving fruits by the use of various protective coverings than would follow the use of the same measures in the summer. At an elevation of 1,500 to 2,000 feet in the Kona district of Hawaii, where the winter mean averages about 68° F., and where the melon fly can breed in large numbers in wild hosts, fully 50 per cent of the pumpkins and squashes are able to mature even if left uncovered. Adults were present at an elevation of 4,000 to 4,500 feet in the island of Hawaii and ovipositing in young squashes. These squashes were examined and found to contain eggs and larvæ. As the vines bearing these fruits were later killed by frosts, it seems possible to conclude, at least for this locality, that the melon fly is able to survive in climates too cold to permit its host plants to grow continuously throughout the year.

## METHOD OF SPREAD.

The melon fly is probably more often carried from one locality or country to another in the larval stage than in any other form. Maskew (42) has recorded finding living larvæ in host fruits arriving at San Francisco on ships from Honolulu, and his records prove that the melon fly in the larval stage is able to bridge the 6 or 7 days required by the slower vessels to cover the 2,000 miles between the Hawaiian Islands and California, since he intercepted it at least once a year during 1912, 1913, 1914, and 1915. Data regarding the duration of the immature stages show that host fruits taken on board ships as ship's stores are capable of carrying the melon fly, either as larvæ or later as pupæ in the fruit containers, for voyages much longer than that required to cross the Pacific Ocean; or, in other words, are capable of being the means of spreading the pest in vessels plying between almost all countries where climatic conditions are favorable for the establishment of the fly. There is no doubt that the melon fly was carried to the Hawaiian Islands in host fruits taken on ships at Japan or China, and later spread from Honolulu to all the islands of the Hawaiian group in a like manner through the medium of inter-island boats.

While the spread, from one country to another at a considerable distance, probably starts with the fly in the larval stage, the spread from town to town, or over short distances, as between islands of an archipelago, may occur in the adult or pupal stage. The writers have seen female flies alight on an automobile top and be carried 16 miles, from the country into the city of Honolulu. On another occasion an adult was seen flying about an inter-island boat en route from Honolulu to Hilo, on the island of Hawaii. This fly was not observed after the boat weighed anchor at the port of Lahaina on the island of Maui, or 72 miles from Honolulu. These two instances will explain the spread of the pest, in the adult stage, about the islands of Hawaii, even if it could not be transported in the larval stage.

When larvæ form their puparia on bare surfaces, and particularly on a cloth surface, the puparia adhere sufficiently well to make it possible for them to be transported considerable distances under favorable circumstances. While the writers know of no instance where the melon fly has been thus spread, distribution in this fashion is quite feasible and to be expected.

## CONTROL MEASURES.

### NATURAL CONTROL.

There are no agencies at present working in the Hawaiian Islands that bring about, even periodically, a very large natural reduction in the abundance of melon flies. The mortality among eggs and larvæ is not sufficient to attract attention, except under conditions considered below, and then is not effective enough to be of practical value as a control measure. Were bacteria and fungous diseases at work, the results of such activities would have been evident to the writers during the past several years. The death rate among adult melon flies must be high, or the natural increase of the pest would produce far greater swarms of them than are now present in fields. While Severin (45) has recorded rearing 3 specimens of the hornfly

parasite (*Spalangia hirta* Haliday) from 500 puparia of the mel
fly, both he and the writers appreciate that this parasite is of
value at present as a control agent, and, for all practical purpos
can not be considered a factor in repression. Although the write
have reared adult flies from many thousands of larvæ, they have neve
reared a parasite during a period of 3 years. This is true, notwithstanding the fact that melon-fly pupæ have been used experimental
(39) in the laboratory for rearing the Mediterranean fruit-fl
parasites, *Opius humilis* Silv. and *Diachasma tryoni* Cam. Fiv
thousand pupæ of the melon fly, secured from Chinese cucumber
(*Momordica* sp.) growing wild near coffee fields in the Kona distric
Hawaii, during 1914 and 1915, produced no parasites, although t
pupæ of the Mediterranean fruit fly secured from the coffee cherrie
showed a parasitism ranging from 85 to 98 per cent.

The great need for methods of natural control has been appre
ciated, and the Hawaiian Board of Agriculture and Forestry em
ployed Mr. D. T. Fullaway to search for and introduce parasit
of the melon fly to Hawaii from the Indo-Malayan regio
Mr. Fullaway has returned to Honolulu after travel in India an
the Philippines, but the results of his investigation have not y
been made ready for publication. It may be stated, however. th
he has introduced an opiine parasite, which gives promise at th
present time (June, 1916) of becoming successfully established i
the Hawaiian Islands.

The mortality among the eggs and larvæ noted occurs chiefly i
rapidly-growing cucurbits, particularly during the cooler seaso
when climatic conditions arrest fly development, but not to the sam
degree as that of the host, and to a less degree in much older frui
during the warmer seasons. Death among eggs and the young larv
follows the development of a gall-like hardening about the eg
cavity, and on occasion about the newly made burrow of the firs
stage larva. This gall-like formation develops rapidly, particularl
in such hosts as the gourd and watermelon. While both of thes
hosts are very susceptible to repeated attacks, individual fruits ofte
succeed astonishingly well in throwing off fatal attack by suc
formations as that illustrated in Plate XXI, figure 1. The write
have seen large gourds used for household purposes by the poor
population which on the outer side of the rind showed the open brea
made by many colonies of eggs and young larvæ, while the insid
showed all ruptures of the epidermis to be sealed by a hard gal
variously formed by the proliferation of plant tissue. The follo
ing data resulting from the examination of a young watermelon
inches in diameter on April 19, 2 days after it was gathered fro
the field. will serve as a fair example to illustrate this mortalit
and are representative of other data on file.

Puncture 1: Twelve unhatched and fresh-looking eggs in a newly made cavity. No gall-like formation evident.

Puncture 2: Nine dead first-stage larvæ and 7 dead third-stage larvæ; all in tough hard gall about one-half inch in diameter.

Punctures 3 and 4 (merged): Eighteen living and one dead first-stage larvæ in a callous dark-brown spot beneath the puncture. Living larvæ moderately active but apparently dying and unable to get out of gall-like formation surrounding them.

Punctures 5 and 6 (merged): Eight living and 6 dead first-stage larvæ in conditions similar to those in punctures 3 and 4.

Puncture 7: Four dead first-stage larvæ dark brown in color.

Puncture 8: Sixteen dead first-stage larvæ dark brown in color.

Puncture 9: Seventeen dead first-stage larvæ dark brown in color.

The data just given would indicate, if considered alone, that the mortality resulting from the gall-like formations might be of practical value; however, under Hawaiian conditions they are of negigible value. In the field from which the watermelon examined was taken, all the very young fruits were badly stung. The 3-inch specimen examined was one of the comparatively few which had resisted attack, and it would have been rendered worthless by the deformities developing about the punctures, even if it did not break down under continued attack by the fly or through decay.

Larvæ die if forced to feed on the decay resulting from bacterial or fungous diseases of the host. While on occasion 90 per cent of all arvæ within a decaying fruit may be found dead, the duration of egg and larval life is so short that mortality resulting from decay is relatively small and unimportant. Mortality among larvæ within bean pods is occasionally due, apparently, to excessive dryness developing with the maturing of the pod. Excessive sun heat kills a few arvæ in fruits well exposed, and the common and abundant introduced harvester ant *Pheidole megacephala* Fab. is responsible for he destruction of some larvæ and adults. In climates colder than he Hawaiian littoral climate mortality due to coldness will be found to play a particularly active part in reducing the abundance of the melon fly. This, however, is not a factor in Hawaii.

### ARTIFICIAL CONTROL.

No satisfactory artificial control measures have been successfully applied in controlling the melon fly under Hawaiian conditions. The only means now employed in Hawaii to safeguard fruits is that of protecting the young fruits with some type of covering until they re large enough to withstand attack. Trapping the adults and killng them by spraying have thus far given poor results, while killing he immature stages by submergence in water, burial in soil, or by old-storage temperatures are methods to be applied in lessening the bundance of the pest only after infestation has taken place within the host fruit. If all growers of host plants would systematically cooperate (1) in the destruction of the eggs and larvæ by submergence in water and (2) in the destruction of the adults by spraying, the value of spraying with a poisoned bait, and of covering the young fruits, would be enhanced to a point where either might be sufficiently effective to be recommended as satisfactory; but so long as the cultivation of host plants is largely in the hands of uneducated orientals who are not amenable to instruction, no relief can be expected.

*Spraying.*—Since adult melon flies do not begin ovipositing until from 10 to 14 days after emergence, depending upon the temperature, but feed continuously throughout this period, it is evident that any spray that will kill them before they begin ovipositing is valuable. Severin (45) and Marsh (27) have shown that poisoned-bait sprays are capable of killing adult flies in large numbers, as has already been demonstrated by Mally and Bezzi in the case of the Mediterranean fruit fly. But good results promised by the work of Mally and Bezzi were found by Severin, Marsh, and the writers in Hawaii to be offset by adverse conditions, such as frequent showers and lack of concerted action by those growing host fruits. Marsh, who sprayed beds of cucumbers with a solution made of 1 quart of molasses, one-fourth ounce of Paris green, and 1½ gallons of water, daily from September 9 to October 14, obtained negative results. This was true also when arsenate of lead was used instead of Paris green. Severin found that sprays containing a soluble poison, such as potassium arsenate or sodium arsenite, killed off enormous numbers of adults quickly but "burned the foliage, and can not be advocated." He was unable by spraying to protect young watermelon plants, because he could not control the outside sources for adults and because of the frequent showers.

The writers have obtained negative results in their work with the poisoned spray:

| | |
|---|---|
| Lead arsenate (paste) | 5 ounces. |
| Brown sugar | 2½ pounds. |
| Water | 5 gallons. |

About 2 acres of Chinese melons and cucumbers in a field fairly well isolated, which from the Hawaiian standpoint means that no host fruits were growing within 500 yards, were sprayed on May 21, 26, and 28, June 1, 4, 8, 14, and 23, 1915, during typical summer weather. At the beginning of the experiments the young fruits were badly stung. Every fruit under 2 inches long was infested unless it had been properly covered, and adult flies were very numerous. The spray was applied at the rate of about 30 gallons to the acre by means of a knapsack sprayer. The abundance of living adults was so noticeably lessened after the third application that even the Chinese gardeners noted the fact, and for the first time during the experiment showed a willingness to cooperate. The interval between June 14 and 23 was sufficient to permit an accumulation of adults equal to that at the beginning of the experiment. Six hours after an application no dead flies could be found, though many were sluggish and flew with difficulty. Twenty-four hours after an application many flies could be found dead among the vines. While the adults were lessened numerically, the young fruits were as badly punctured at the end of the experiment as at the beginning. Dr. Illingsworth, of the College of Hawaii, has had only negative results in his experiments to save cucurbit crops by spraying, although he has been able to kill large numbers of adults.

While the writers have had negative results with poisoned-bait sprays, they feel that their failure has been due to peculiar conditions surrounding the fields sprayed. Under commercial conditions, where cantaloupes, pumpkins, and watermelons are grown in large quantities in fairly dry climates, it is reasonable to believe that sufficiently good results will follow the use of poisoned sprays to make their application practicable as a method of control. In Hawaii the growing of these crops is in the hands of Orientals, who do not appreciate the necessity for clean cultural methods as an adjunct to spraying. Their gardens, scattered here and there, form excellent breeding places and centers of distribution. These conditions, coupled with the very long life of the adult and its roving disposition, make it impossible to protect small fields of host plants in Hawaii at the present time by spraying, particularly during the warm season of the year.

*Cold storage.*—The only data on the effect of cold-storage temperatures upon the immature stages of the melon fly are those included in Tables VIII and IX. Fewer experiments have been carried on by the writers to determine the effect of cold-storage temperatures upon the melon fly than upon the Mediterranean fruit fly, since it has been found that the stages of the former are not more resistant. Consequently host fruits refrigerated for periods sufficiently long to kill the Mediterranean fruit-fly eggs, larvæ, and pupæ are free from danger as carriers of the melon fly; i. e., if refrigerated at from 40° to 45° F. for 7 weeks; from 33° to 40° F. for 3 weeks; or from 32° to 33° F. for 2 weeks when the humidity ranges between 80 and 91. A comparison of the data in Tables VIII and IX with those already published on cold-storage effects upon the immature stages of the Mediterranean fruit fly indicates that the eggs and larvæ of the melon fly and Mediterranean fruit fly are about equally resistant to cold-storage temperature, but that the pupæ of the melon fly are much more susceptible. While no pupæ of the melon fly survived refrigeration at from 32° to 33° F. or from 34° to 36° F. for 5 days, or from 36° to 45° F. (averaging 38° F.) for 9 days, pupæ of the Mediterranean fruit fly were not found to be entirely killed until refrigerated for 10 days at 32° F., 18 days at 33° to 36° F., or 21 days at 38° to 40° F. No larvæ of the melon fly survived more than 14 days of refrigeration at 35° to 36° F., or 36° to 40° F.; no larvæ of the Mediterranean fruit fly survived more than 12 days at 34° to 36° F., 11 days at 36° to 40° F., or 20 days at 38° to 40° F. No eggs of the melon fly survived cold storage at 35° to 36° F. and 36° to 40° F. for more than 10 days, while no eggs of the Mediterranean fruit fly were found alive after refrigeration at 36° F. and 36° to 40° F. for 12 days.

It is anticipated that these data will be of special value from a quarantine standpoint. The favorable host fruits of the melon fly are fruits which do not adapt themselves to long periods of refrigeration and are subject to serious attack only when they are very young and succulent, except such fruits as the cantaloupe, cucumber, and tomato. The melon-fly host fruits are classed among the quickly perishable fruits, unless exception be made of certain varieties of well-matured squashes and pumpkins. In experimental work the writers have had difficulty in keeping host fruits in fit condition until the larvæ infesting them had been killed by refrigeration. This was particularly true at the temperature of 49° F.

TABLE VIII.—*Effect of cold-storage temperatures upon eggs and larvæ of the melon fly.*

| Number of days in cold storage. | Temperature of storage room. | Eggs. | | Larvæ. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number under observation. | Number hatching after removal from store. | First instar. | | Second instar. | | Third instar. | |
| | | | | Number alive. | Number dead. | Number alive. | Number dead. | Number alive. | Number dead. |
| | *°F.* | | | | | | | | |
| 7 | 35 to 36 | 3 | 1 | 8 | 64 | 48 | 77 | 89 | 145 |
| 10 | .......... | 67 | 0 | 1 | 595 | 2 | 364 | 14 | 440 |
| 12 | .......... | 172 | 0 | 0 | 260 | 0 | 215 | 4 | 218 |
| 14 | .......... | 47 | 0 | 0 | 172 | 0 | 299 | 0 | 336 |
| 16 | .......... | 52 | 0 | 0 | 85 | 0 | 288 | 0 | 301 |
| 18 | .......... | 32 | 0 | 0 | 263 | 0 | 363 | 0 | 515 |
| 20 | .......... | 0 | 0 | 0 | 243 | 0 | 379 | 0 | 676 |
| 22 | .......... | 31 | 0 | 0 | 134 | 0 | 265 | 0 | 318 |
| 6 | 36 to 40 | 75 | 15 | 85 | 124 | 12 | 49 | 12 | 13 |
| 7 | .......... | 14 | 0 | 19 | 10 | 43 | 34 | 25 | 63 |
| 9 | .......... | 78 | 1 | 0 | 65 | 0 | 114 | 2 | 18 |
| 10 | .......... | 0 | 0 | 0 | 49 | 5 | 78 | 51 | 223 |
| 11 | .......... | 147 | 0 | 0 | 124 | 0 | 105 | 0 | 140 |
| 12 | .......... | 0 | 0 | 0 | 60 | 0 | 45 | 5 | 196 |
| 13 | .......... | 78 | 0 | 0 | 107 | 0 | 104 | 0 | 25 |
| 14 | .......... | 0 | 0 | 0 | 78 | 0 | 155 | 1 | 320 |
| 15 | .......... | 72 | 0 | 0 | 96 | 0 | 82 | 0 | 84 |
| 17 | .......... | 135 | 0 | 0 | 35 | 0 | 126 | 0 | 61 |
| 18 | .......... | 0 | 0 | 0 | 48 | 0 | 130 | 0 | 291 |
| 20 | .......... | 0 | 0 | 0 | 64 | 0 | 122 | 0 | 256 |
| 22 | .......... | 0 | 0 | 0 | 21 | 0 | 126 | 0 | 108 |
| 7 | 49 to 52 | 87 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | .......... | 83 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 49 to 52 | 282 | 0 | 51 | 13 | 1 | 30 | 17 | 11 |
| 10 | .......... | 107 | 34 | 16 | 63 | 66 | 16 | 74 | 13 |
| 12 | .......... | 31 | 0 | 0 | 6 | 2 | 9 | 32 | 49 |
| 17 | .......... | 72 | 0 | 20 | 44 | 0 | 4 | 19 | 10 |
| 21 | .......... | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 76 |
| 23 | .......... | 250 | 0 | 0 | 8 | 0 | 0 | 11 | 12 |

TABLE IX.—*Effect of cold-storage temperatures upon the pupæ of the melon fly.*[1]

| Temperature of storage room.[2] | Number pupæ under observation. | Age on entering storage. | Number of pupæ yielding adults after removal to normal temperature after refrigeration for— | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 3 days. | 4 days. | 5 days. | 7 days. | 9 days. | 11 days. | 13 days. | 15 days. | 17 days. | 19 days. | 21 days. |
| *° F.* | | *Days.* | | | | | | | | | | | |
| 32° to 33°.. | 425 | 2 | 7 (100) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 785 | 3 | 5 (125) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1,020 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1,945 | 5 | 0 | 1 (245) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3,175 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2,165 | 7 | 4 (200) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34° to 36°.. | 505 | 2 | 7 (90) | ....... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 640 | 3 | 5 (45) | ....... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 985 | 4 | 6 (175) | ....... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2,390 | 5 | 2 (145) | ....... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2,104 | 6 | 3 (195) | ....... | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1,813 | 7 | 9 (195) | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36° to 45°.. | 1,975 | 6 | 21 (170) | ....... | 12 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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[1] Numbers in parentheses refer to total numbers of pupæ removed after refrigeration for the length of days indicated.

[2] Average, 38° F.

*Submergence in water.*—Submergence of host fruits containing the immature stages of fruit flies has been recommended by many writers as an easily available method of controlling these pests. Severin (45) has published the first data on the effects of submergence upon the melon fly. In his work he submerged beneath 7 inches of distilled water three lots of 100 full-grown larvæ which had emerged from their hosts to pupate. One lot was removed after having been submerged 2, 3, and 4 days. After being allowed to dry upon filter paper, 75, 16, and 0 larvæ pupated and later yielded 47, 5, and 0 adults, respectively. From these data Severin concluded that submergence of infested vegetables in a barrel or tank of water for a period of 4 days would be sufficient to insure the death of larvæ within them.

Instead of submerging isolated larvæ, the writers have submerged infested cucumbers in ordinary tap water at a mean temperature of 78° F. The results of daily examination of the larvæ within these fruits on submergence from 1 to 6 days are given in Table X. It will be noted that many larvæ survive a submergence of 1 and 2 days successfully. On the third day but 6 out of 207 larvæ in the second and third instars were found living. But 1 out of 374 larvæ withstood submergence 4 days. All of 514 and 773 larvæ found in fruits submerged 5 and 6 days were dead.

Pupæ submerged in tap water survived slightly longer than larvæ, as indicated by the data in Table XI. Fourteen out of 52 pupæ that were from 2 to 4 days old when immersed yielded adults after removal from the water. Only 1 out of 77 pupæ of like age submerged 5 days survived and yielded an adult, while all of 91 submerged 6 days died. The young pupæ apparently die more quickly than the older pupæ when submerged. Only 2 of 79 pupæ 1 and 2 days old, respectively, survived submergence for 2 days. Two out of 156 and 1 out of 163 pupæ submerged 3 and 4 days, respectively, survived. Other pupæ 1 and 2 days old submerged 5, 6, and 7 days died.

It is safe to conclude that the larvæ of the melon fly will be killed when the host containing them is submerged in water for 5 days and the pupæ after submergence for 6 days.

TABLE X.—*Effect of submergence in ordinary soft water upon larvæ of the melon fly within cucumbers.*

[Daily mean temperatures for period 69.5° to 71° F., averaging 70.5° F.]

| Date of immersion. | Date of removal. | Date of examination. | Dead larvæ. | | Living larvæ. | | Number days immersed. | Number fruits examined. |
|---|---|---|---|---|---|---|---|---|
| | | | Third instar. | Second instar. | Third instar. | Second instar. | | |
| Jan. 15 | Jan. 16 | Jan. 17 | 16 | 15 | 239 | 63 | 1 | 22 |
| Do | Jan. 17 | Jan. 18 | 21 | 19 | 139 | 52 | 2 | 37 |
| Do | Jan. 18 | Jan. 19 | 155 | 46 | 6 | 0 | 3 | 24 |
| Do | Jan. 19 | Jan. 20 | 256 | 117 | 1 | 0 | 4 | 29 |
| Do | Jan. 20 | Jan. 21 | 317 | 197 | 0 | 0 | 5 | 41 |
| Do | Jan. 21 | Jan. 22 | 512 | 261 | 0 | 0 | 6 | 61 |

TABLE XI.—*Effect of submergence in ordinary soft water upon pupæ of the melon fly at a mean temperature of 78° F.*

| Lot No. | Number of pupæ under observation. | Date of pupation. | Date of immersion. | Date of removal. | Number of adults emerging. | Date of emergence. |
|---|---|---|---|---|---|---|
| 1 | 396 | June 19–22 | June 24 | June 26 | 9 | June 30 |
| | | | | | 90 | July 1 |
| | | | | | 108 | July 3 |
| | | | | | 19 | July 4 |
| | | | | | 4 | July 5 |
| | | | | | 3 | July 6 |
| | | | | | 1 | July 8 |
| 2 | 106 | do | do | June 27 | 32 | July 3 |
| | | | | | 15 | July 4 |
| | | | | | 8 | July 5 |
| | | | | | 4 | July 6 |
| 3 | 52 | do | do | June 28 | 2 | July 3 |
| | | | | | 7 | July 4 |
| | | | | | 1 | July 5 |
| | | | | | 3 | July 6 |
| | | | | | 1 | July 7 |
| 4 | 77 | do | do | June 29 | 1 | July 10 |
| 5 | 91 | do | do | June 30 | 0 | |
| 6 | 79 | June 22–24 | do | June 26 | 2 | July 5 |
| 7 | 130 | do | do | June 27 | 1 | July 7 |
| 8 | 26 | do | do | do | 1 | July 3 |
| 9 | 15 | do | do | June 28 | 1 | July 12 |
| 10 | 148 | do | do | do | 0 | |
| 11 | 101 | do | do | June 29 | 0 | |
| 12 | 117 | do | do | June 30 | 0 | |
| 13 | 170 | do | do | July 1 | 0 | |

*Burial in soil.*—Van Dine (19) recommended that all melons and vines infested with the melon fly should be buried to the depth of several inches. Severin (45) has shown quite conclusively that unless great care is taken thoroughly to tamp soil filled in over such infested material adults can emerge from pupæ and finally burrow their way to the surface from a depth of from 2 to 3 feet of dry sand; 34, 8, and 5 adults, respectively, from lots of 500 pupæ buried 2 feet deep succeeded in reaching the surface through dry sand, wet sand, and soil. Fifty-four 3-day-old pupæ were placed in the center of 10 square inches of heavy black soil, such as is found in the market-garden section of Waikiki. On drying out this soil hardened so that no adults were able to emerge. One hundred larvæ which had emerged ready for pupation were placed on the surface of the same heavy black soil just mentioned, which had been thoroughly wet, as though well irrigated. All the larvæ pupated on or close to the surface and 70 yielded adults. The soil was so tenacious on drying that the remaining 30 per cent which were just beneath the surface were unable to emerge.

Burial of the host for the destruction of the immature stages of the melon fly is not a method of control to be recommended. The labor necessary properly to bury infested material is so great that few lots will be buried to a sufficient depth, and cracks formed in the soil by rapid decay and settling furnish avenues for the escape of adults from fully 95 per cent of all material, even when buried in the most tenacious soils.

*Traps.*—Howlett states[1] that he was able in India to attract the males of the two closely related fruit flies, *Dacus zonatus* Saund. and *D. diversus* Coq., by exposing citronella oil. He was not able to attract specimens of either sex of the melon fly. Although he was successful in attracting these two species with citronella oil, he failed to get any reaction with such individual derivatives of this oil as were obtainable (citrol, citronella, geraniol, citronellaldehyde, citronellol). Later he believed that he had found the actual substances which are responsible for attracting these two fruit flies in iso-eugenol and methyl-eugenol. By exposing the closely related eugenol he succeeded in attracting the male of an apparently new species. Samples of eugenol sent by Howlett to Severin and given the writers by the latter gentleman failed to attract melon flies when exposed in infested districts.

The mango fruit fly (*Dacus ferrugineus* Coq.) was found by Froggatt (26) to be attracted by citronella oil, but Illingworth states[2] that the railroad worm (*Rhagoletis pomonella* Walsh) avoids citronella oil. It is now well known that the males only of the Mediterranean fruit fly are attracted in any numbers to ordinary kerosene. In Honolulu the writers have seldom caught adults of the melon fly in this oil, although they have had traps hung throughout the infested district for many months. Severin was not able to catch a sufficient number of melon flies in various oils to feel that they were in any way actually attracted. He used the following oils: Citronella, turpentine, coconut, whale, fish, kerosene about 120° Baumé, gasoline about 86° Baumé, and benzine about 63° Baumé. Turpentine, gasoline, and benzine caught no flies. The other oils, exposed over a 5-day period, caught from 2 to 5 individuals, representing both sexes.

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[1] Howlett, F. M. The effect of oil of citronella on two species of Dacus. Trans. Ent. Soc. Lond., 1912, Pt. II, p. 412–418, pl. 39, 40. 1912.

[2] Illingworth, James F. A study of the biology of the apple maggot, etc. Cornell Univ. Agr. Exp. Sta. Bul. 824, p. 160. 1912.

Ordinary flytraps baited with diluted molasses and hung about infested fields were found by Severin to be worthless.

*Protection of fruit by covering.*—The attack upon cucurbits of all varieties is so universal in Hawaii that the female bloom in all species except the cucumbers should be covered before the corolla unfolds or immediately after. During the warmer portion of the year the bloom of cucurbits should be protected at least 3 or 4 days before the flower unfolds in order to insure protection. At present many fruits are so covered, but rather indifferently and ineffectually, as proved by an examination of fruits beneath the coverings. Thus during April only 9 out of 43 fruits of the Chinese melon (*Momordica* sp.) that had been covered were sound, while at Waipahu on the same date 119 out of 692 young protected watermelons were actually free from infestation. Certain Japanese growers ward off attack by burying the young fruit in the soil or surrounding it by straw and trash until it is sufficiently old to need no further protection. However, the usual practice among both Japanese and Chinese growers is to place over the developing bud or the recently opened flower a piece of cheesecloth or other fabric. This averages in size about 6 to 7 inches square and is placed lightly over the fruit without any attempt to attach it to the plant, although in certain cases it may be weighted on the edge with earth. The most successful of the protective coverings are those shown in Plate XXIV. In this case the Momordica vines are grown in bushes where the young fruits can be easily found and inclosed in the long case made from newspapers. These cases are left open at the lower end, but are never entered by the adult flies.

The protection of fruits by covering with soil, paper, or cloth is a great labor-consuming operation that at present actually protects less than 25 per cent of all fruits covered, except certain Chinese marrows. This method is, however, at present the only one which can be applied with any degree of success, and could be made far more successful were it applied more intelligently. In a slightly cooler climate a very much higher percentage of fruits could be saved.

## SUMMARY.

The melon fly (*Bactrocera cucurbitae* Coq.) is found well distributed over India, which is considered its native home. It is at present found in India, Ceylon, Java, Timor, Northern Australia, Singapore, the Philippine Islands, southern China, Japan, and the Hawaiian Islands. It was introduced into the Hawaiian Islands from Japan about 1895, and by 1897, when it was first observed, it was already a serious pest. Up to the present time it has been allowed to increase unrestricted, and because of the equable climate and abundant food supply has become a serious pest of cucurbitaceous crops, cowpeas, string beans, and tomatoes. It is impossible to overstate the destructiveness of the melon fly to cucurbitaceous fruits under Hawaiian littoral conditions, where these can be brought to maturity only with the exercise of the greatest care on the part of market gardeners.

It has been estimated that the melon fly causes a loss of about three-quarters of a million dollars in a territory smaller than the State of Rhode Island. It is a pest of prime importance that is being intercepted each year by officers of the Federal Horticultural Board in ships arriving at the California coast from Honolulu and Hilo, and there is, therefore, great danger of the melon fly being introduced to the continental United States.

During the warmest seasons in Hawaii, when the mean temperatures average about 79.5° F., the egg, larval, and pupal stages may be passed in as few as 12 or as many as 28½ days, according to the individual and host conditions. At mean temperatures lower than 79.5° F. the duration of the immature stages may be greatly increased. Thus at 51.6° F. the pupal stage alone may require 59 days and the egg 11 days, while at 56° to 62° F. the first and third larval stages may require 27 and 23 days, respectively. Under varying conditions of host, temperature, and humidity the immature stages may be lengthened from a minimum of 12 days to 3½ to 4 months. Adults may live as many as 431 days, although the duration of adult life is variable and may be but a few days. Adults deprived of food and water never live more than 102 hours or more than 120 hours without food but with water. This is also true of adults which have been feeding for some time when placed under starvation conditions. The complete life cycle may, therefore, occupy from 443 to 459 days in the case of most hardy individuals passing the egg, larval, and pupal stages during the warmest seasons, but longer when these stages are passed during colder seasons.

Adults feed principally upon the juices of host plants, nectar of flowers, and honeydew secreted by a large number of insects. While the melon flies are rapid fliers and are found often far from their host plants, they appear to arrive at these points as the result of roving rather than by long-sustained flights. During the warmest seasons they are active in feeding and ovipositing chiefly during the early morning and late afternoon hours. In captivity they mate about sunset and when fed upon papaya and water, copulate only when about 20 or more days old, with the mean temperature averaging 75.5° F. and the relative humidity 69.3 per cent. No eggs were obtained from females under these conditions until 32 days after emergence. During the winter, also, when fed upon papaya and water, when the mean temperature was 71° F. and the relative humidity 78.5 per cent, no eggs were deposited until 44 days after emergence. However, when fed on cucumber, in captivity, mating will commence when the adults are only 10 days old and egg-laying begins the following day or only 11 days after emergence, when the mean temperatures average 76.4° F. and the relative humidity is 69.1 per cent. Having once begun ovipositing, adults continue to deposit batches of from 1 to 37 eggs every few days throughout life. One female deposited eggs when 398 to 400 days old. Another, emerging on May 25, 1914, deposited 687 eggs between July 15, 1914, and February 27, 1915. It is estimated that particularly hardy individuals may deposit as many as 1,000 eggs. The average number of eggs deposited is much less and extremely variable.

Adults deposit their eggs within the tissues of the host fruit in cavities made with the aid of a sharp ovipositor. Eggs may be deposited in all portions of the plant and fruit, including the crown, leaf petioles, stalks, and blossoms. If deprived of host plants adults will oviposit, although less frequently, upon other objects, at least in confinement. They were able to keep alive by feeding on the food supplied them in the laboratory during a period of what happened in experimental work to be from 13 to 31 to 37 weeks when no host plants were available for oviposition, and began ovipositing at a normal rate as soon as host plants were available.

Larvæ upon hatching usually burrow to the center of the host plant or fruit, although the place where they feed is determined largely by the moisture content of the host. In young seedlings they may burrow into the taproot and kill the plant. In succulent plants they burrow through the leaf petioles and stalks and bring about a progressive pruning back of vines by causing the death of affected parts. The staminate and pistillate bloom and the fruits are variously affected, as described and illustrated elsewhere. After passing through three instars the larvæ leave the host to pupate in the soil, usually beneath the host, at a depth ranging downward to 2 inches. Larvæ are aided in leaving the fruit and seeking suitable places for pupation by their ability to jump, in stages, from 6 to 8 inches. If they are not able to enter the soil they will pupate upon any hard surface, such as a floor, corners of fruit cases, burlap coverings, etc.

Since there are as many as 8 to 10 generations of the melon fly a year, it is evident that it can multiply very rapidly. No agencies have been found to be working at the present time in Hawaii that bring about, even periodically, a great natural reduction in the abundance of melon flies. In colder climates cold weather will prove a marked and valuable control factor. No parasites are known in Hawaii. Predacious enemies and several forms of mortality recorded are of no practical value under Hawaiian conditions. Search for parasites is now in progress and it is hoped that future introductions of melon-fly parasites may prove beneficial.

No satisfactory artificial measures have been successfully applied in combating the melon fly under Hawaiian conditions. Poisoned-bait sprays promise to yield effective results under other cultural conditions. At present cucurbits can only be grown by the use of coverings of various sorts for the protection of the very young fruit. Trapping of adults and killing adults by sprays have yielded negative results, while killing the immature stages by submergence in water, by burial in soil, or by cold-storage temperature are methods to be applied in lessening the abundance of the pest after infestation has occurred. Artificial methods of control are not likely to prove satisfactory in Hawaii so long as the growing of the chief host plants remains in the hands of uneducated oriental laborers who do not practice clean cultural methods or cooperate in applying remedial measures.

## BIBLIOGRAPHY.

(1) CLARK, B. O.

1898. *In* The Hawaiian, vol. 1, No. 27, p. 6.

The Hawaiian was a newspaper published only during 1898. Mr. L. H. Mesick, Hawaiian Gazette Co., Honolulu, its editor, possesses the single known complete file. One section of the paper was known as the official bulletin of the Bureau of Agriculture (now the Board of Agriculture and Forestry). The reference consists of correspondence containing the first information published regarding the presence of the melon fly in the Hawaiian Islands, or elsewhere, and is as follows:

LAUPAHOEHOE, *August 8, 1898.*

Prof. KOEBELE, *Honolulu.*

DEAR SIR: We have a new pest that has lately come here in the shape of a fly like a yellow jacket, only not so large. It punctures pumpkins, squashes, bean, tomatoes, watermelons, and all other plants of this nature. It lays eggs inside, which form maggots like the samples I send you. You can judge of their work where the things are growing. Can you suggest any remedy? I send you some samples of their work by the S. S. *Kinau.*

Yours, truly,

L. C. SWAIN.

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HONOLULU, *August 11, 1898.*

L. C. SWAIN, Esq., *Laupahoehoe, Hawaii.*

DEAR SIR: Yours of the 8th instant at hand and contents noted. Prof. Koebele is now in the States, but as I have personal experience with the fly you mention and consulted with Prof. Koebele in regard to it, I can state he told me of no remedy except covering the vines, and of course this is not at all practicable except for a few vines in a garden. I tried a spray of whale-oil soap, thinking the odor might keep the fly away, but it did not. I shall try a Paris-green solution, 1 pound to 200 gallons of water, keeping it stirred frequently, and apply with a spray pump. This will kill the eggs and young larvæ of the codling moth on apple and other fruits, and possibly may do so in this case. The great difficulty in this climate is that frequent showers wash off the poison, and it has to be repeated frequently. The Paris green can also be applied as a powder, mixed with flour or air-slaked lime, in the proportion of 1 part of Paris green to 100 of flour or lime. I would advise collecting all infested squashes and feeding to pigs or other animals or bury them so deep the fly can not get out when it hatches. If all who grow the crops which it breeds in would do so, I think it could be at least checked; the great difficulty would be to know if there is any wild fruit, etc., upon which it deposits its eggs for development. I have not observed it attacking anything but the cucumber, melon, and squash family.

The following life history, which I have learned by experimenting in a "hatchery," may interest you if you have not already determined the same for yourself. The fly which you describe is more like a small-sized botfly than a wasp, and will be seen hovering about the vines of muskmelons, squashes, etc., and when disturbed darts away very quickly, so rapid, in fact, one can scarcely follow it with the eye. It stings not only the fruit with its ovipositor, but also the young and tender growth of the vines, depositing a number of eggs, which soon hatch into small white maggots that feed on the tissues of the plant or fruit, causing it to decay. After the maggot has attained its growth, it descends into the soil, where it develops into a small chrysalis of a light yellowish-brown color, and in about 10 or 12 days comes out a perfect insect, ready to repeat its mission of destruction. I do not know how many generations it will produce in a year, but in the warmer and drier districts I believe it will breed the year through, except possibly a while during the winter months, and then its development is only retarded by the cooler weather, which prevents the chrysalis maturing so rapidly.

If you will take a squash or other specimen with the eggs or young maggots in the same, placing it in a box containing 2 or 3 inches of loose, dry soil, keeping it covered with a piece of glass, you can soon learn for yourself its life history, and perhaps make observations that may lead to means of successfully combating the pest.

Yours, respectfully,

BYRON O. CLARK,
*Secretary and Commissioner of Agriculture.*

**(2) COQUILLETT, D. W.**

1899. A new trypetid from Hawaii. *In* Ent. News, v. 10, No. 5, p. 129–130.

**This article, which is technical and contains the original description of *Dacus cucurbitæ*, is as follows:**

*Dacus cucurbitæ* n. sp. Head light yellow, the occiput, except the sides and upper margin, reddish yellow, an ocellar black dot, front marked with a brown spot in front of its center and with three pairs of orbital brown dots, a black spot on each side of the face near the middle, and a brown spot on the middle of each cheek; antennæ, palpi, and proboscis yellow, the latter mottled with brown. Thorax reddish yellow, the humeri, a median vitta on the posterior half of the mesonotum, another on each side above the insertion of the wings, uniting with an irregular band which extends upon the pleura to the upper part of the sternapleura, also a large spot on each side of the metanotum. encroaching upon the hypopleura, light yellow; scutellum, except its extreme base, light yellow, bearing two bristles. Abdomen light yellow on first two segments, reddish yellow on the others, the extreme base, a fascia at the bases of the second and third segments, usually a lateral spot on the fourth and fifth, also a dorsal vitta on the last three segments, blackish or brownish; first segment of the ovipositor of the female slightly longer than the fifth segment of the abdomen. Wings hyaline, the apex of the subcostal cell from a short distance in front of the apex of the auxiliary vein, the marginal and submarginal cells, the median third of the first basal cell, and a large spot in upper outer corner of the first posterior cell, brown; anal cell brown, this color encroaching on the third posterior cell and bordering the sixth vein almost to its apex: posterior cross vein bordered with brown, this color extending to the hind margin of the wing; upper end of the small cross vein also bordered with brown. Halteres light yellow. Legs light yellow, the broad apices of the femora and the last four joints of the tarsi reddish yellow, hind tibiæ reddish yellow or dark brown. Length 6 to 8 mm.

Honolulu, Hawaii. Two males and two females bred by Mr. George Compere from larvæ living in green cucumbers. Type No. 4207, U. S. Nat. Museum

**(3) HOWARD, L. O.**

1900. A dipterous enemy of cucurbits in the Hawaiian Islands, *In* U. S. Dept. Agr. Div. Ent. Bul. 22, n. s., p. 93–94.

**In this short account Dr. Howard gives data on the prevalence of the melon fly about Honolulu, secured by George Compere, at the time of his visit to the Hawaiian Islands in November, 1898. Reference as follows:**

March 13, 1899, we received from Mr. George Compere, Honolulu, Hawaiian Islands specimens of what is locally known as the melon or cucumber fly. Our correspondent. writing under date of February 14, 1899, states that this is a very serious pest with vegetable growers, as it destroys more than 75 per cent of the watermelons, cantaloupes, and cucumbers grown in those islands. He writes, in substance, that the parent flies are to be found at all seasons of the year, and that they puncture the cucumber, which is the only plant on which our correspondent has observed the species, on the upper side, and generally near the stem end, this operation taking place when the cucumber is about half or two-thirds grown. In the punctures thus made they deposit their eggs, which soon hatch into minute footless white maggots. Their presence in the cucumber is manifested by a small yellow spot where the puncture was made. Twenty-seven minute maggots were counted in one of these punctures. In one cucumber that had been punctured three times in different places, 116 of these maggots were counted. These maggots eat out the entire inner substance of the fruit with the exception of the seeds. leaving only the outer skin, which turns yellow and decays, when a slight touch or a few drops of rain will cause it to collapse. By that time the maggots have all attained their growth, and if any of them become exposed to the sunlight they immediately draw themselves together and, after the manner of the cheese maggot and other species that might be mentioned, spring in all directions, jumping as high as 3 feet. If the skin of the cucumber be left intact they will emerge from the decayed pulp on the underside and burrow at once into the earth for pupation. Fourteen days after placing maggots in a breeding jar, with soil kept constantly moist, Mr. Compere succeeded in obtaining the adult flies.

In the conclusion of this letter our correspondent adds, as a warning, that watermelons, cantaloupes, and cucumbers should never be allowed to be shipped from the

Hawaiian Islands into the United States. It is quite probable that this insect could be introduced into several of our Southern States or recently acquired insular possessions, and it is one of those species for which quarantine inspectors should be on the lookout. No class of vegetables, if we except cabbages and botanically related plants, are so badly infested with insects as are the cucurbits, and the introduction of another new pest is most undesirable.

The insects were referred to Mr. Coquillett, of this office, who after careful examination pronounced the species an undescribed Trypetid. He has accordingly given it the name of *Dacus cucurbitæ*, and has published a description of it in the Entomological News for May, 1899, under the title "A New Trypetid from Hawaii."

(4) **Koebele, Albert.**

1900. Report of Prof. A. Koebele, entomologist. *In* Rpt. Comr. Agr. and Forestry, Hawaii, p. 36–49.

Among injurious pests treated he calls attention to the fact that *Dacus cucurbitæ* is the only species of fruit fly so far known in Hawaii, that it is almost impossible to raise cucurbitaceous fruits without proper protection to the plants, and suggests cooperation in clean cultural methods as the only feasible manner of combating the pest.

(5) **Howard, L. O.**

1901. Diptera collected in Hawaii by H. W. Henshaw. *In* Proc. Ent. Soc. Washington, v. 4, no. 4, p. 490.

Among the Diptera *Dacus cucurbitæ* Coq. is listed with the statement: "Five specimens. Described from Hawaii." '

(6) **Grimshaw, P. H.**

1901. Fauna Hawaiiensis. (v. 3, pt. 1, 77 p., 3 pl. Cambridge.)

Reference consists merely of copy of (2) and statement of Howard (5).

(7) **Craw, Alexander.**

1902. Horticultural quarantine reports. *In* Bien. Rept. Bd. Hort. Cal., v. 8, 1901–2, p. 187–204.

Reference consists of a paragraph of seven lines, giving the first official record of the interception by quarantine officers of melon-fly infested material from Honolulu at San Francisco. Reference as follows (p. 198):

> We occasionally find a melon in the possession of passengers or crews from Honolulu, which we destroy. No melons, cucumbers, or summer squashes have been received as freight from Honolulu since we destroyed the shipment that arrived on February 28, 1899, on the S. S. *Australia,* infested with melon maggots (*Dacus cucurbitæ*). In Honolulu this pest destroys 75 per cent of their crop. It is not found in North America.

(8) **Perkins, R. C. L.**

1902. Insects. *In* Rept. Governor of Territory of Hawaii for 1902. Ann. Rpts. U. S. Dept. Int., pt. 2, p. 360.

An 8-line reference, recounting difficulty of growing cucumbers, except under cover, as a result of melon-fly attack. "Its true home is no doubt either Japan or China. At Hongkong a species is found almost identical in size, color, and form, and which only differs in having an additional pair of bristles on the scutellum. Parasites of the melon fly could no doubt be procured from that country."

(9) **Smith, J. G.**

1902. *In* Ann. Rpt. Hawaii. Agr. Exp. Sta., U. S. Dept. Agr. Off. Exp. Stas. Rpt., 1902, p. 324.

Four-line reference as follows: "A fly is doing great damage to the cucurbits by stinging and depositing its eggs in the young fruit. The larvæ, on hatching, burrow into the tissue, causing decay. As a result a good watermelon brings from 50 cents to $1 on the fruit stands of Honolulu.

(10) **Smith, J. G.**

1903. *In* Ann. Rpt. Hawaii. Agr. Exp. Sta., 1903, U. S. Dept. Agr. Off. Exp. Stas. Rpt, 1903, p, 417.

A 2-line reference to an investigation of melon-fly ravages at Wahiawa, Oahu.

(11) **Van Dine, D. L.**

1904. Insecticides for use in Hawaii. *In* Hawaii. Agr. Expt. Sta. Bul. 3, 21 p., 7 fig.

A 5-line reference as follows, p. 7:

> Watermelons and muskmelons are a luxury, a good melon bringing 50 cents to $1 at the fruit stands in Honolulu. These products could be raised in certain sections, in quantities great enough to bring them within the reach of every table, were it not for the attack of the melon fly (*Dacus cucurbitæ*).

(12) Van Dine, D. L.

1904. Entomological work. *In* Ann. Rpt. Hawaii. Agr. Expt. Sta., p. 372–379.

Reference as follows (p. 376): "The melon fly (*Dacus cucurbitæ*) is a true fly of the family Trypetidæ. The larva infests the fruit of all plants of the family Cucurbitaceæ; destructive also to beans and tomatoes."

(13) Craw, Alexander.

1905. Report of superintendent of entomology. *In* 1st Rpt. Bd. Agr. and Forestry Hawaii, p. 136–146.

Reference is as follows (p. 138): "The melon fly (*Dacus cucurbitæ*) was unfortunately introduced here a few years ago from Japan. That pest has practically stopped the production of muskmelons here. It also attacks other melons, besides cucumbers, squash, tomatoes, and even string beans."

(14) Krauss, F. G.

1905. The vegetable garden. *In* Hawaii. Forester and Agr., v. 2, no. 11, p. 353–361.

The author states in a discussion of melons that "were it not for the ravages of the cut-worms, plant lice, and the melon fly these crops would be delightful to grow in Hawaii, but our advantages from the absence of frost are about offset by the prevalence of insect pests."

(15) Terry, F. W.

1906. A preliminary account of insects of economic importance in the Hawaiian Islands. *In* Haw. For. and Agr., v. 3, no. 2, p. 35–45.

Discusses *Dacus cucurbitæ* in 24 lines of print (p. 44). "Since its arrival it has practically stopped the raising of melons, cucumbers, squashes and tomatoes in many localities, unless these plants are carefully screened from the attacks of the fly." Popular notes on life history and description of very general nature.

(16) Van Dine, D. L.

1906. The melon fly (*Dacus cucurbitæ* Coquillett). *In* Haw. For. and Agr., v. 3, no. 4, p. 127–129.

A 3-page popular account of a most general nature. States that during last season the crop of melons exceeded any previous crop since the advent of the fly, probably due to the perseverance of Japanese growers in protecting their melons from the fly at or immediately after the setting of the fruit.

(17) Craw, Alexander.

1907. Reports of horticultural quarantine inspection work. *In* Hawaii. For. and Agr., v. 4, no. 5, p. 113–116.

From dead specimens of the "melon fly" (*Dacus cucurbitæ*) received by this division from the government entomologists of India, we learn of the existence of several parasites that prevent its seldom or ever becoming a pest there. An effort should be made to introduce these parasites here by way of Hongkong. This would be a difficult experiment, owing to the great distance, but the undoubted benefit to the melon industry of this Territory, in case these parasites were successfully introduced and established, would justify the expenditure of considerable money in the attempt to control this pest.

(18) Maxwell-Lefroy.

1907. The more important insects injurious to Indian agriculture. *In* Mem. Agr. Dept. India, Ent. Ser., v. 1, p. 113–252, 80 fig.

Page 228 states that this is a sporadic and occasionally serious pest which hibernates during cold months and is found in hot weather and rains. Gives distribution as "Nasik, Pusa, Hathwa, Surat, Umballa. Probably throughout India."

(19) Van Dine, D. L.

1908. Report of the entomologist. *In* Ann. Rpt. Hawaii. Agr. Expt. Sta. 1907, p. 25–51, 3 fig., 2 pl.

The melon fly, p. 30–35: A good concise article of 5½ pages, containing copies of (1), (2) and (17), the first illustrations of adult, eggs, larva and puparium ever published, a complete bibliography to date, besides general statements regarding ravages and control.

(20) Howlett, F. M.

1909. Diptera. *In* Maxwell-Lefroy's Indian Insect Life, p. 545–664, pl. 58–71, fig. 348–423.

No text regarding *Dacus cucurbitæ* but figures adult female, eggs in gourd, larva and pupa, together with anterior and posterior spiracles of pupa, p. 633, fig. 4, 8.

(21) Kirkaldy, G. W.

1909. Entomological notes. *In* Haw. Planter's Record, v. 1, no. 2, p. 32.

Short note stating that some parasites of the melon fly left with the Hawaiian Board of Agriculture and Forestry by Geo. Compere were being investigated by the Entomological Division of the Hawaiian Sugar Planters' Association. (See (23) for further information.)

(22) Blackman, L. G.

1909. Our melon pest. *In* Hawaii. Forester and Agr., v. 6, no. 8, p. 281.

Calls attention to an estimated loss of three-quarter million dollars annually to Hawaii as a result of melon-fly attack and to the need of a search for and the introduction of parasites of the melon fly.

(23) Kotinsky, J.

1909. Report of the superintendent of entomology for July, 1909. *In* Hawaii. Forester and Agr., v. 6, no. 9, p. 358–361.

Gives result of investigation referred to in (21). Records the rearings from pupæ of *Ceratitis capitata* sent by Geo. Compere from West Australia. Consignment on arrival at Honolulu, June 24, 1909, was turned over to the Entomological Division of the Hawaiian Sugar Planters' Association. Summarizes investigations made by O. H. Swezey, of the Hawaiian Sugar Planters' Association (see p. 364–365), by saying that a few adults of *Ceratitis capitata* emerging first were allowed to die in the rearing vials before removal; that although 115 specimens of *Chalcis* (probably *Tetrastichoides* sp.) emerged and were placed with melon-fly maggots no mating or oviposition was noted and no maggots became parasitized. Seven specimens of a braconid (*Apodesmia* sp.) were reared, but no mating or attempts at oviposition were noted, and no parasitism followed the confinement of these parasites with cucumbers infested with maggots of *Dacus cucurbitæ*.

(24) Bezzi, M.

1909. Le specie dei generi Ceratitis, Anastrepha e Dacus. *In* Bol. Lab. Zool. Portici, v. 3, p. 273–313.

*Dacus cucurbitæ*, p. 294 and 300. Purely systematic reference.

(25) Van Dine, D. L.

1909. Report of the entomologist. *In* Ann. Rpt. Hawaii. Agr. Expt. Sta., 1908, p. 17–41.

Page 32, a 5-line reference as follows: "It is believed that at the present price of melons it would pay to grow muskmelons at least under cover, fertilising the flowers by colony of bees."

(26) Froggatt, W. W.

1909. Report on Parasitic and Injurious Insects. Dept. Agr. N. S. Wales, 1907–1908, p. 53, 54, 56, 84–85, pl. 11, figs. 6, 7.

Records *Dacus cucurbitæ* from gardens about Allahabad, India, and Jaffna, Ceylon. States that *Dacus cucurbitæ* was not attracted to citronella oil, although other species of *Dacus* were; that Muir found India the native home of *D. cucurbitæ*, and that his own later investigations showed that it was widely distributed over India and Ceylon; found *Dacus cucurbitæ* wherever melon gardens were examined in Central and Northwestern India; reared it from melons, cucumbers, bitter gourd, and eggplant.

(27) Marsh, H. O.

1910. Report of the assistant entomologist. *In* Rpt. Bd. Comrs. Agr. and Forestry, Hawaii, p. 152–159.

Forty-three lines of print calling attention to utter disregard by oriental gardeners of clean cultural methods and resultant increase of *Dacus cucurbitæ* about Honolulu. Discusses results of spraying with poison baits and use of trap crop. In the latter cantaloupes were used with cucumbers with negative results, since both crops were entirely destroyed. Spraying experiments in which a solution of molasses 1 quart, Paris green ¼ ounce, and water 1¼ gallons was used, gave negative results, although applied daily from September 9 to October 14. A solution with arsenate of lead also gave negative results.

(28) Ehrhorn, E. M.

1910. Report of the superintendent of entomology. *In* Hawaii. Forester and Agr., v. 7, no. 11, p. 336–338.

Record of rearing one adult melon fly from sweet orange from Kaimuki, Oahu.

(29) Perkins, R. C. L.

1911. The Mediterranean Fruit Fly. *In* The Hawaii. Planters' Record, v. 4, no. 3, p. 140–144, 3 fig.

Article is entirely on *Ceratitis capitata,* but contains by way of illustration for comparison a good figure of the adult female *Dacus cucurbitæ.*

(30) Banks, Nathan.

1912. The Structure of Certain Dipterous Larvæ, with Particular Reference to those in Human Food. U. S. Dept. Agr. Bur. Ent. Tech. Ser. 22, 44 p., 8 pl.

Reference as follows, p. 32, pl. 5, fig. 101, 102, 104:

*Dacus cucurbitæ* Coq. Head bilobed from above, each lobe bearing a distinct antenna; mandibles two, distant; anterior spiracles long, with about 20 lobes. Ventral segments 6 to 12 with swollen spinulose areas. The last segment shows below a transversely elliptical spinulose area, rather depressed, and containing two approximate, flat, rounded tubercles; tip of body rounded, with a low, broad swelling at each lower corner; the stigmal plates are approximate, each with three short slits, pointing toward those of the opposite plate.

From melons in Hawaii.

Gives figures of side view of head, anterior spiracle, and stigmal plate of larva.

(31) Weinland, H. A.

1912. The fruit fly menace and preventive measures. *In* Mo. Bul. State Com. Hort. Cal., v. 1, no. 5, p. 156–159.

While dealing chiefly with *Ceratitis capitata,* Weinland has the following to say about *Dacus cucurbitæ:* "The melon fly has been a pest on the Hawaiian Islands for as many as 25 years and has become established on all the islands of the group. It is particularly destructive to melons and certain vegetables. On March 28, 1910, Quarantine Order No. 4 was issued barring from the State watermelons, muskmelons, cucumbers, and tomatoes from these islands or from any other place in which the fly is known to exist."

(32) Cook, A. J.

1912. The work of the State commissioner of horticulture. *In* Mo. Bul. State Com. Hort. Cal., v. 1, no. 8, p. 372–377; no. 9, p. 533–539.

Two references identical and as follows: "I am happy to inform you that we have enlisted the interest and action of other Pacific Coast States and of British Columbia, and so feel that we are in less danger of an invasion of the Mediterranean fruit fly and of the melon fly (*Dacus cucurbitæ*) via other than our own ports through the interest and action of horticulturists of other States."

(33) Compere, Geo.

1912. A few facts concerning the fruit flies of the world. *In* Mo. Bul. State Com. Hort. Cal., v. 1, no. 10, p. 709–733, fig. 204–219.

Pages 709–710, discovery of *Dacus cucurbitæ* in Honolulu in November, 1898; p. 723, record of collections about Poona, India; p. 845, record of collections at Colombo, Ceylon; p. 909, record of rearing material collected at Bangalore, India; states that he found the melon fly a rather serious pest at Macao and Canton, but "not to the extent it is in the Hawaiian Islands." Figure 212 reproduces photo (2) wing of melon fly from India and (3) from Hawaii.

(34) Green, E. E.

1912. Report of the government entomologist. *In* Rpt. Dept. Agr. Ceylon, pt. 4, 1911–1912, p. 2–5.

Lists the pumpkin fly (*Dacus cucurbitæ* Coq.) as destructive to fruits of vegetable marrows.

(35) Essig, E. O.

1913. Some interesting fruit flies. *In* Mo. Bul. State Com. Hort. Cal., v. 2, no. 11, p. 726.

Gives C. F. Baker as authority for information that *Dacus cucurbitæ* Coq. is abundant in the Philippine Islands.

(36) Bezzi, M.

1913. Indian trypaneids (fruit flies) in the collection of the Indian Museum. *In* Mem. Indian Mus., v. 3, no. 3, p. 53–175, pl. 8–10, 3 fig.

*Bactrocera cucurbitæ* Coquillett, p. 96–97, pl. 8, fig. 7 (wing):

"A proportionally large species which can be easily recognized from all other known Indian species by the posterior cross-vein of the wings being widely bordered with brown. Vertical, thoracic, and scutellar bristles black. Third abdominal segment of the male with a row of black bristles; anal stripes dilated at tip, but less abruptly than in the preceding species [*mangifera*]." States that this species has been found widely distributed over India and Ceylon, and that this region is its original home. "In the collection are many specimens from Calcutta, caught in April, May, June, and September; others from Durjbana, Nepal Terai, Ranchi; Kumdlik, Nepal Terai, in March; Bhogaon, Purneah district, N. Bengal, in October; Allahabad, United Provinces, in August; Nepalganj, Nepal Frontier, 22–xi–11; Siripur; Saran, N. Bengal, 26–ix–10; Adra, Manbhum district, 12–x–09; Bombay, in gourds, 12–x–03; Peradeniya, Ceylon, 10–i."

States, on page 366, that while he reared four species of Dacus from Fijian fruits he did not find Cucurbitaceæ.

(38) Muir, F.

1914. Observations in Formosa. *In* Hawaiian Planters' Record, v. 10, no. 4, p. 274–281.

In 3-line reference, p. 281, states "*Dacus cucurbitæ* and *Dacus diversa* (*c*) are both common and do harm—the former to cucumbers, melons, etc.; the latter to citrus fruits. No parasites are known to attack them."

(39) Bridwell, J. C.

1914. Report for the period from October 1 to December 31 [1913]. *In* Hawaii. Bd. Agr. and Forestry Bul. 3, p. 154–160.

States that development of melon fly is not retarded by winter weather and that melon-fly pupæ may be used experimentally in rearing parasites for *C. capitata.*

(40) Rutherford, A.

1914. Report of the entomologist. *In* Rpt. Dept. Agr. Ceylon, July 1, 1912, to December 31, 1913, p. 9–12.

Lists *D. cucurbitæ* among various insects of economic importance.

(41) Dammerman, K. W.

1914. Het Vraagstuk der Fruit-vliegen voor Java. Dept. van Landbouw, Nijverheid En Handel. Meddelingen van de Afdeeling voor Plantenziekten, no. 8, p. 7–8, pl. 2, fig. 1. (wing).

States that in Java has bred *Dacus cucurbitæ* from Momordica and Citrullus, and lists as feeding in melons, watermelons, and cucumbers. Article of value chiefly as reference to presence of pest in Java.

(42) Maskew, F.

1914. Report of investigations of the fruit-fly situation in the Territory of Hawaii. *In* Mo. Bul. State Com. Hort. Cal., v. 3, no. 6, p. 227–238.

Report deals chiefly with *Ceratitis capitata,* but contains the following: "The melon fly (*Dacus cucurbitæ*) is a source of great financial loss to the producers, and all of its hosts should be included in the list of material covered by the United States quarantine order."

(43) Fletcher, T. B.

1914. Some South Indian Insects. 565 p., 50 pl., 440 fig. Madras.

Page 354 states that the melon fly is a serious pest to cucurbits through southern India, where it passes through the egg, larval, and pupal stages in about 15 days. Recommends prompt gathering and deep burial of all infested fruits and protection of fruits by coverings of netting. Colored plate 26 gives good enlarged dorsal view of adult fly and figures of larvæ and pupæ. Illustrations same as appearing in (20), only enlarged and colored.

(44) Fullaway, D. T.

1914. Report of the entomologist. *In* Ann. Rpt. Hawaii. Agr. Exp. Sta., 1913, p. 18–21.

Lists of insects affecting various garden crops with approved notes. Lists *Dacus cucurbitæ* as affecting cabbage, eggplant, tomatoes, peppers, and cucumbers.

(45) **Severin**, H. H. P., **Severin**, H. C., and **Hartung**, W. J.

1914. The ravages, life history, weights of stages, natural enemies, and methods of control of the melon fly (*Dacus cucurbitæ* Coq.). *In* Ann. Ent. Soc. Amer., v. 7, no. 3, p. 177–207, pl. 27–31, 4 fig.

Most comprehensive paper dealing with *Dacus cucurbitæ* thus far published. Of special interest from standpoints of new and for most part original data and illustrations of pest's capacity for damage, and for data on length of egg, larval, and pupal stages, weights of various stages, and control by submergence in water, burial in sand and soil, traps, and poisoned sprays.

(46) **Back**, E. A., and **Pemberton**, C. E.

1914. Life History of the Melon Fly. *In* Jour. Agr. Res., v. 3, no. 3, p. 269–274.

Preliminary to present bulletin, giving data on length of egg, larval, and pupal stages, and upon longevity, sexual maturity, and rate of oviposition of adults during the warmer periods of Hawaiian weather. First report of careful biological work in which the important influence of temperature is taken into consideration.

(47) **Fullaway**, D. T.

1915. Report of the entomologist. *In* Rpt. Hawaii. Agr. Exp. Sta., 1914, p. 43–50.

Reference as follows (p. 49): "The melon fly (*Dacus cucurbitæ*) has often been reported infesting the heart of cabbage, but the infestation is not at all common and is considered to be due to abnormal conditions in the plant and of a secondary nature."

(48) **Severin**, H. H. P.

1915. Experiments in destroying fruit infested with fruit fly maggots. *In* Ent. News, v. 26, no. 2, p. 78–83.

Deals with both *C. capitata* and *D. cucurbitæ*. Contains 1¾ pages of compilation from other authors, 2½ pages taken verbatim from (34), and 1 page of conclusions and bibliography. Tables and figure appear in (34).

(49) **Maskew**, F.

1915. Report of the quarantine division for the years 1912, 1913, 1914, and 1915, appearing in Mo. Bul. St. Com. Hort., Vols. II, III, and IV.

Records the interception at San Francisco of contraband material from Honolulu containing living larvæ of *Dacus cucurbitæ* during July, 1912, June and September, 1913, and June, 1914. No melon flies were intercepted during 1915 unless covered by the "tomatoes infested by trypetid larvæ" recorded for November.

(50) **Hill**, G. F.

1915. Insect Pests of Plants. Northern Territory of Australia. Dept. External Affairs. Melbourne. Bul. no. 13, 16 p.

*Dacus cucurbitæ* Coq. is listed as pest of melons, pumpkins, and marrows, among some of the principal insect pests of trees and crops at present grown in the Northern Territory.

(51) **Bryan**, W. A.

1915. Natural History of Hawaii. 596 p., 117 pl., Honolulu.

Six-line paragraph dealing in a general way with the melon fly as one of a number of important pests introduced into Hawaii, p. 387.

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Office of the Secretary
Contribution from the Office of Farm Management
W. J. SPILLMAN, Chief

Washington, D. C. PROFESSIONAL PAPER February 10, 1917

# AN ECONOMIC STUDY OF FARMING IN SUMTER COUNTY, GA.

By

H. M. DIXON, Assistant Agriculturist, and H. W. HAWTHORNE,
Scientific Assistant

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## INTRODUCTION.

This bulletin embodies a study undertaken with a view to determining the relative importance of the several factors which made for success or failure in the management of representative farms in central Georgia. An analysis was made of the business of each of 534 such farms in Sumter County to bring out the economic significance of such factors as tenure, size of farm, farm organization, crop yield, and cost of cotton production.[1]

The Sumter County area, where the study was made, is strictly a cotton-growing section, more than one-half of the land in cultivation being devoted to that crop and 89 per cent of all farm receipts coming from that source. Roughly speaking, one-third of all farm lands in the county are in cotton, one-third in woods, and the remainder in other crops and pasture. The farms studied vary in size from the 50-acre tenant farm to the 5,000-acre plantation. On about one-fourth of the farms the owner reduces risk and responsibility by renting out part of his acreage. Of 217 farms operated by colored farmers, only a few are owned, and nearly all are of less than 100 acres. Seven out of every ten of these farms are worked almost entirely by the negro operator and his family. The general system of operation in vogue in Sumter County is typical of farming operations throughout a large part of the cotton belt.

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[1] The authors wish to acknowledge their indebtedness to the many farmers of Sumter County through whose courteous cooperation this work was made possible.

Note.—This bulletin is a report on an exhaustive study of farming in a representative county in the cotton belt and is of interest to cotton growers especially.

## SUMMARY OF RESULTS.

Following is a brief résumé of the more significant facts brought out or substantiated by this investigation:

Farm profits on these farms for the year of the survey (1913) were in direct proportion, both to the number of acres in crops and the yield of cotton per acre.

On farms of approximately the same size, labor incomes were high when the yield of cotton was high and low when the yield was low.

On owner farms of approximately the same size labor incomes were high when percentage of crop area in cotton was high, and vice versa.

The white farmers of the area are getting a much higher yield per acre than the colored farmers.

Cotton, corn, oats, and cowpeas, in order, are the more important crops of the region.

Cotton occupies 59 per cent of the tilled area of the farms surveyed and returns 89 per cent of the total farm receipts.[1]

Corn occupies over one-fourth of the tilled area and was grown on every farm visited. Oats are the principal small-grain crop and are also used for hay and pasture. Cowpeas for hay and seed occupy about half as much land as corn. About 85 per cent of the land utilized for a second crop in 1913 was in cowpeas.

The cost of producing cotton, computed for 534 farms, was found to average about 10.5 cents per pound of lint.

The cost of producing cotton on these farms decreases with increase in size of farm. The relative rate of reduction in cost due to increase in acreage is greater for the farms ranging from small to medium than for those ranging from medium to large.

The cost of producing cotton on these farms decreases with increase in yield per acre. The reduction due to increased yield is relatively greater for farms with yields ranging from low to medium than for farms with yields ranging from medium to high.

On farms with high yields of cotton per acre the cost per acre was high but the cost per pound low.

Aside from work stock, hogs constitute the most important class of live stock.

Of the cash expenditures of these farms, labor and fertilizer together represent three-fourths or more of the total.

In efficiency in utilizing labor, mules, and machinery, the large farms have a great advantage over the small ones. On the small white-owner farm one mule works 10 acres of cotton and 11 acres of other crops, while on the large farm one mule works 19 acres of cotton and 10 acres of other crops.

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[1] This percentage of receipts is based on a price of 12 cents per pound.

The cotton type of farming enables men with but very little capital to begin farming. The average capital of colored tenant farmers was but $491, yet the average income of these negroes and their families was $506.

On the white-owner farms the intensive type of farming practiced in this section raises cash expenditures to over 60 per cent of total receipts. If the receipts from cotton should at any time fall off 40 per cent from the average for 1913, these farms would barely pay expenses and would return nothing for capital or for labor done by the operator.

The colored share cropper realizes 50 pounds of cotton and 4 bushels of corn more per acre than the colored tenant.

## SOURCES OF INFORMATION.

The best source of agricultural information is the farm. From the individual farmer who has long years of experience may be obtained data that will determine approximately the factors which govern his income. A consensus of such individual data will determine approximately the factors which govern the prosperity of any agricultural region. In the agricultural region involved in this study, devoted almost exclusively to one type of farming, can be found examples of various forms of farm organization and of various farm methods and practices. Some of the farms in this region are yielding much larger profits than others. Some farmers through efficient operation are realizing a good annual income and at the same time building up their farms, while others who are apparently working just as earnestly are barely able to make both ends meet. The data secured in such an investigation as this serve to bring out in relief the vital factors of farm practice which account for this difference. The data presented herewith, representing the experience of 534 southern farmers, should be applicable, not only to the area covered by the study, but to a large portion of the southern district where like conditions and a like type of farming prevail.

## AREA STUDIED.

Sumter County is in the southwestern part of Georgia (see fig. 1). Americus, the county seat, situated near the center of the county, is about 150 miles south of Atlanta, 185 miles west of Savannah, and 95 miles north of the Florida State line. Practically the entire county is represented in this study, except small areas in the northeastern and northwestern districts.

### HISTORY.

The county was laid out in 1831 from part of Lee County. The first inhabitants came mostly from the older districts of the State. The present population is 29,092, of which 7,849 are white and 21,243 are colored. The county contains 291,840 acres, of which 276,834 acres are in farms. The land was originally owned in very large tracts, but during recent decades many of these large farms have been cut up, so that there now exist a good many small and medium-sized farms.

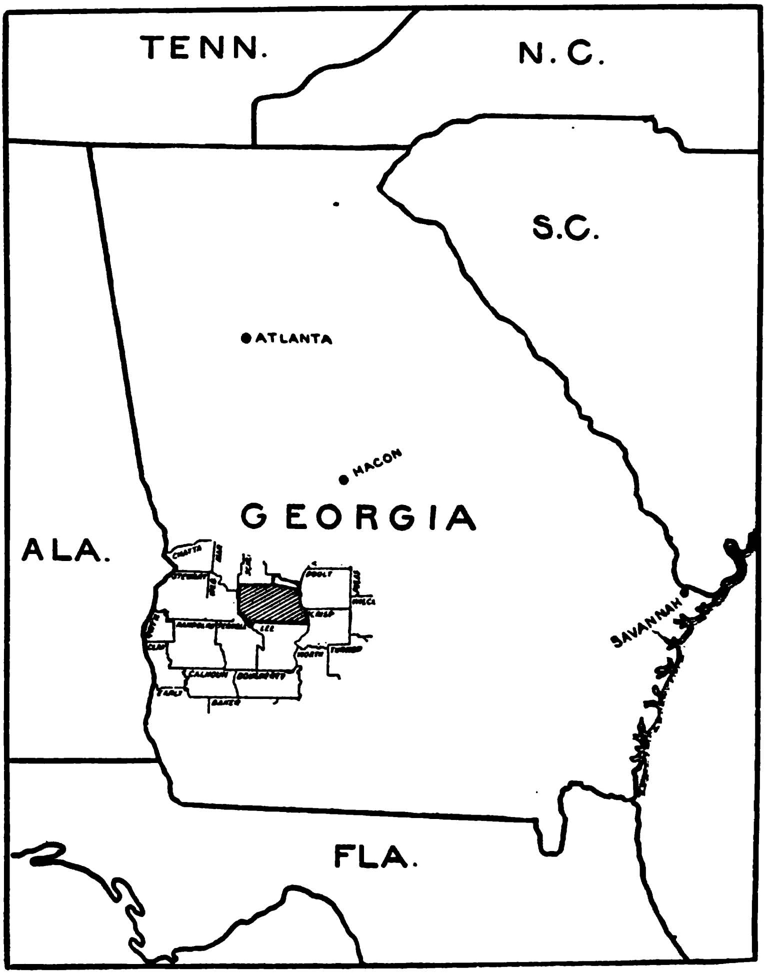

FIG. 1.—Shaded area shows location of county in which farms studied were located (Sumter County, Ga.).

The county is served by two railroads, which furnish very good transportation facilities. The main line of the Central of Georgia crosses the county from north to south through Americus. The Seaboard Air Line enters the county on the west and, passing through Plains, goes northeast to Americus, thence southeast through the small towns of Leslie, Desoto, and Cobb in the southeastern section of the county. Practically all the main wagon roads of the county are in excellent condition.

### SOILS AND TOPOGRAPHY.

Sumter County lies wholly within the Coastal Plain, its northern boundary being 28 miles south of the Piedmont line.[1] The soils are predominantly sandy, this type occupying about 75 per cent of the total land area of the county.[2]

The topography of the county varies from very rolling in the northern portion to very gently rolling or flat in the southern part. The general slope is from northwest to southeast, and practically all the streams flow in a southeasterly direction.

### CLIMATE.

The climate of this county is characterized by summers long but not extremely hot, and short, mild winters.

The average rainfall as recorded by the United States Weather Bureau at Americus, Ga., for the 10 years 1904 to 1913, inclusive, was 47 inches. (See fig. 2.) October and November are the two months with the lowest average rainfall during this period. During the 10 years there was an average of 24 inches of rainfall from April 1 to September 30, which is an abundance for crop production in this region when distributed over this period as evenly as is shown by figure 2.

The rainfall for the year of the study (1913) was 45 inches, or only 2 inches below the 10-year average. During that year the rainfall was well distributed throughout the growing season. It was a little below normal during the months of April and May, but for

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[1] Soil Survey, Sumter County, Ga., U. S. Dept. of Agriculture, Field Operations of the Bureau of Soils, 1911.

[2] The most important soil division of the county, one which occupies 88.7 per cent of its total land area, comprises the soils derived from unconsolidated water-deposited material under good drainage conditions. This soil division contains four distinct series. The first and most important is the Greenville. The soils of this series are of a reddish-brown to dark red color, with a dark red subsoil. This series occupies 63.9 per cent of the total land area of the county. The Norfolk soil series is second in importance and occupies 16.9 per cent of the area of the county. The Norfolk soils are characterized by the gray color of the surface soils and the grayish-yellow to yellow color of the subsoils. This series also has a somewhat lower agricultural producing value than the Greenville series. The Orangeburg soil series occupies only 2.5 per cent of the land area of the county. The soils of this series are of a gray color, with red subsoils. The Orangeburg soils are closely related to the Greenville, differing mainly in the gray color and loose structure of its soils, the subsoil being quite like that of the Greenville. The several types of the Orangeburg series are not so productive as the corresponding types of the Greenville series. The fourth series of this division is represented by the Tifton soil and occupies 5.4 per cent of the area of the county. These soils are gray to brown in color, with yellow subsoils. Ironstone pebbles are abundant.

The second soil division of agricultural importance to this region is known as the Portsmouth series. This soil comprises 2.9 per cent of the land area of the county. The Portsmouth soils, formed under poor drainage conditions, from probably the same material that gives rise to the Greenville, Orangeburg, Norfolk, and Tifton, are characterized by the dark-gray to black color of the surface soil and the light-gray or mottled gray, yellow, and red of the subsoil.

Other soil divisions which are of only minor importance to the agricultural region as a whole are the Sumter stony sandy loam, the low meadow land, the swamp land, and the old alluvial soil.

June, July, August, and September there was an average of 4.8 inches of rainfall per month.

## METHOD OF PROCEDURE.

The method used in getting together the data upon which this bulletin is based was adopted by the Office of Farm Management after long experience with different means and methods.[1]

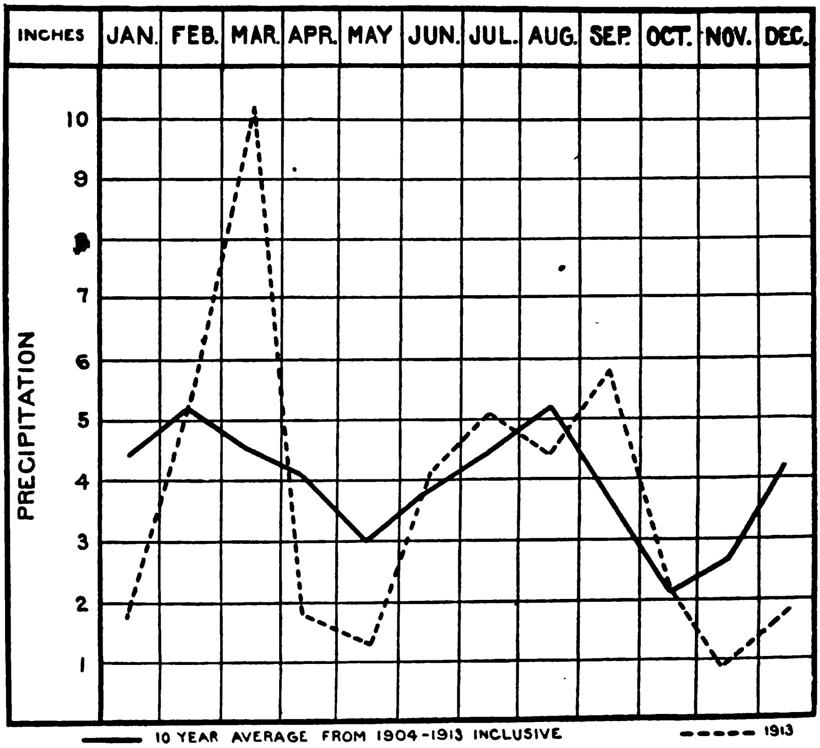

FIG. 2.—A comparison of the rainfall of Sumter County in 1913 with the 10-year average from 1904 to 1913, inclusive.

During the months of April and May, 1914, investigators from the Office of Farm Management familiar with southern agriculture visited Sumter County and made a study of farm-management problems in that region. These men visited each farm in this locality and made a complete record of a year's business transactions, together with an inventory of all the farm investment for the beginning and for the end of the farm year. The farm year in this locality extends from January 1 to January 1, and the particular year to which these data pertain is 1913. In all, records from 665 farms were received, but as a number of these were incomplete or obviously inaccurate, only 534 records were used for the basis of this study.[1]

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[1] An outline explaining the use of this method, together with copies of the blank forms used, may be obtained by applying to the U. S. Department of Agriculture for Farmers' Bulletin 661.

## UTILIZATION OF THE FARM AREA.

The farms in this area range in size from about 50 acres to over 5,000 acres. On many of them a large proportion of the acreage is in woodland, which is seldom used except for supplying wood for the upkeep of buildings and fences, and on a few of the farms in supplying a little winter employment in cutting wood for sale. On account of a very wide variation among individual farms in the proportion of the total area that is used for the farm business, it was necessary in this study to use as a measure of the farm business the number of acres of tilled land rather than the total number of acres. In all tables in this bulletin where farms are classified into groups by size of farm, the area of tilled land is used as the basis.

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[1] In order to present the data clearly, certain terms which will be used throughout the discussion are here defined. It is important that the reader thoroughly understand these terms, as they will materially assist in the interpretation of the results.

*Tilled area.*—The tilled area is the number of acres of the farm devoted to raising crops.

*Farm capital.*—The farm capital is the average value of all real estate, improvements, machinery, live stock, and other investment necessary to carry on the farm business. It includes the value of the farmhouse, but not the household furnishings.

*Receipts.*—The farm receipts include the amount received from the sale of crops, the net increase from stock, and the receipts from outside labor, rent of buildings, etc. The net increase from stock is found by subtracting the sum of the amount paid for stock purchases and the inventory value at the beginning of the year from the sum of the receipts from stock products, sales of live stock, and the inventory value at the end of the year. If the value of crops or supplies was greater at the end of the year than at the beginning, the difference was considered a receipt.

*Expenses.*—The farm expenses represent the amount of money paid out during the year to carry on the farm business, plus the value of the labor performed by the family. If the value of crops or supplies at the end of the year was less than at the beginning, this was considered an expense. Household or personal expenses are not included.

*Farm income.*—The farm income is the difference between the receipts and expenses. It represents the amount of money available for the farmer's living above the value of family labor, provided he has no interest to pay on mortgages or other debts.

*Labor income.*—The labor income is the amount that the farm operator has left for his labor after 5 per cent interest on the average capital is deducted from the farm income. It represents what he earned as a result of his year's labor after the earning power of his capital has been deducted. In addition to the labor income the operator received a house to live in, fuel (when cut from the farm), garden products, milk, butter, eggs, etc.

*Owner.*—The term "owner" is applied when the entire operation of a farm is directed by the man who owns the farm or by someone hired in his stead.

*Owner additional.*—The term "owner additional" is used when the man who owns and directs the operation of a farm rents additional land and operates it in connection with his own as one farm.

*Owner with part rented out.*—When a man owns a farm and directs the operation of part of it, renting the other part out for a specified amount, and assuming little or no responsibility for its operation, he is termed an owner with part rented out.

*Tenant.*—When a man rents a farm, furnishes all labor and equipment, directs its entire operation, and pays the landlord cash or a fixed amount of cotton for the use of the land he is termed a tenant.

*Landlord.*—The landlord is the person who owns a farm which is rented to a tenant.

A general idea of the way in which the land in this county is utilized may be formed by a glance at figure 3. Crop land occupies something over one-half (54.2 per cent) and woodland about one-third (32.6 per cent) of the total farm area. The remainder of the land is in waste, pasture, and idle crop land, the idle crop land occupying almost as much as the pasture land, and the waste land occupying a little more than these two combined.

In Table I the 268 farms operated by white owners are arranged in six groups by size of farm, in order to show the utilization of land and the value of real estate per acre on farms of different size. The farms in these groups vary in average size from a total farm area of 63 acres with 33 acres of crops in the first-size group, to a total of 1,625 acres with 827 acres of crops in the last-size group.

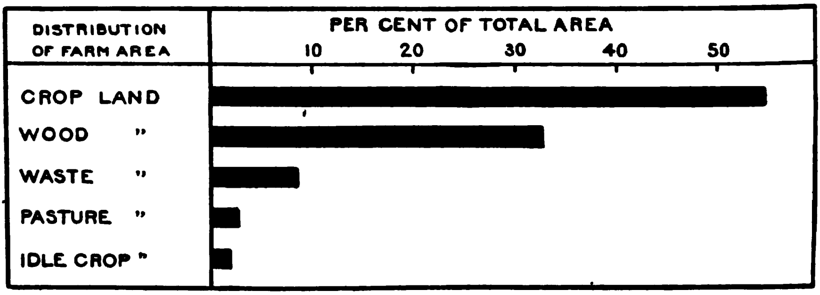

FIG. 3.—Percentage distribution of land area on 268 farms, Sumter County, Ga.

TABLE I.—*Utilization of land and value of real estate per acre on 268 farms operated by white owners, owners additional, and owners with part rented out (Sumter County, Ga.).*

| Item. | Groups of farms based on tilled area per farm. | | | | | | All farms. |
|---|---|---|---|---|---|---|---|
| | 50 acres and less. | 51 to 100 acres. | 101 to 150 acres. | 151 to 250 acres. | 251 to 450 acres. | Over 450 acres. | |
| Number of farms | 36 | 64 | 56 | 47 | 30 | 35 | 268 |
| Area per farm ........ acres | 63 | 151 | 201 | 325 | 566 | 1,625 | 419 |
| Tilled area per farm ........ do | 33 | 77 | 123 | 197 | 321 | 827 | 226 |
| Per cent of farm in— | | | | | | | |
| Tillable land | 60.2 | 55.6 | 65.4 | 65.9 | 61.0 | 54.3 | 58.4 |
| Crops | 52.0 | 51.3 | 61.3 | 60.7 | 56.7 | 50.9 | 54.2 |
| Idle crop land | 5.9 | 2.5 | 2.2 | 1.6 | 2.6 | 1.1 | 1.9 |
| Pasture | 2.4 | 2.9 | 2.6 | 4.4 | 2.7 | 2.4 | 2.7 |
| Woodland | 30.7 | 36.3 | 25.1 | 23.7 | 31.3 | 36.5 | 32.6 |
| Waste land | 9.0 | 7.0 | 8.8 | 9.6 | 6.7 | 9.1 | 8.6 |
| Value of real estate per acre | $34.00 | $34.00 | $39.00 | $40.00 | $37.00 | $31.00 | $34.80 |

While there is some variation among the groups in the proportion of land that is tillable, there is no direct relation between the size of farm and tillable area. The table shows that 58.4 per cent of all the farm area is tillable, and that two of the size-groups, that of from 51 to 100 acres and that of over 450 acres, fall below this proportion.

and that these two groups are those having the highest proportion of woodland.

The proportion of the total farm area utilized for crops is shown in figure 3, and the variation from this proportion for the several size-groups is shown in Table I. The smallest two and the largest of the groups each has about one-half of its farm area in crops, while two of the intermediate groups each has slightly over six-tenths of its farm area in crops. The size-groups vary somewhat in the proportion of farm area utilized for crops, but this variation is irregular and without apparent significance.

With the exception of the smallest size-group of farms, there is a remarkable uniformity in the proportion of tillable land utilized for crops. Beginning with the smallest, this proportion, expressed in percentage of the tillable area, is 86, 92, 94, 92, 93, and 94, with an average of 93 for all farms. This shows that practically all the land immediately available is being used for crops. The small additional acreage that might possibly be used for crops at the present time is the area lying idle and that utilized as pasture land, in all less than 5 per cent of the total farm area. Thus unless more land is cleared, it is impossible to increase materially the present crop acreage.

The tillable land lying idle usually consists of fields badly run down in productiveness. In a few instances land was idle because the cropper or renter had moved in the late spring, leaving the owner unable to obtain additional labor to farm the area relinquished. On the average 1.9 per cent or 8 acres of the farm area was idle crop land.

The percentage of farm area devoted to pasture is very uniform throughout the several size-groups, averaging 2.7 per cent. This would naturally be expected, as practically the only pasture land necessary under the present type of farming in this section is that for work stock and other live stock to furnish supplies for the home and for hired labor.

Woodland constitutes 32.6 per cent of the land area on these farms. The more common trees are long-leaf pine, oak, beech, maple, dogwood, and elm, of which long-leaf pine is the most valuable for lumber. The land area occupied by forests is mostly along the streams and in the low swampy areas.

The waste land, which comprises all the area taken up by buildings, roads, streams, and other nonproductive ways, is fairly uniform in all size-groups, varying from 6.7 to 9.6 per cent, with an average of 8.6 per cent for all farms.

There is a variation in the value of real estate per acre in the several size-groups, without relation to the size of farm. That it is affected primarily by the percentage of farm land in crops is evidenced by the fact that the highest real-estate values occur in the groups ranking high in percentage of crop area. The lack of a correlation between size of farm and value of real estate per acre is perhaps due to social conditions more than to any other one factor.

In other tables it is shown that only the large farms can support an overseer or manager, and that on these large farms the operator's time is almost entirely taken up in the supervising of the business. The operator of the large farm can therefore, if need be, live at a distance from his farm lands, choosing a community where his family can have the best advantages. Usually the small farmer is not able to do this and is often compelled to live under very undesirable conditions. The location of many of these small farms is such that they will not sell for more per acre than large plantation land. The average value of real estate on the 268 farms was $34 per acre.

## FARM TENURE.

In this study, which covers the data received from 534 farm operators, there were found 299 farmers owning a part or the entire farm operated; 268 of these farms were owned by white and 31 by colored farmers; the other 235 farms were operated by tenants, of which 49 were white and 186 colored.

The owner-farms were operated under three distinct forms of tenure, namely, that of "straight owner," or those who have the entire supervision of all their farming land; "owner renting additional," or those who not only operate their own land but also rent additional land and operate this along with their own farm as one unit; and "owner with part rented out." The latter usually include the larger farms, the owners of which in order to shift a share of the responsibility and to experience less risk, rent out a part of their farms to tenants, who furnish the working capital, perform all the labor, and give the owners a fixed amount of lint cotton for the use of the land. It is on farms held under this last-mentioned tenure that many of the tenants included in this study, especially the colored tenants, were found. The farms operated by tenants are all comparatively small, but the farms operated by owners comprise, in many cases, several thousand acres.

The economic and social conditions of the South are of a very different nature from those of the northern States, and the fact that these conditions are changing from time to time makes necessary readjustments of the relations of races. In 1860 the negroes represented 52 per cent of the total population of the county, in 1880 they represented 66 per cent, and in 1910, 73 per cent. This condition is attributable not only to natural increase, but to an increased demand for negro labor in this fertile section over that of less productive regions. Separate schools and churches have to be built for each race, and thus farms are sometimes located a long distance from community centers. Under the type of farming followed at present in this region the two races are not separated into distinct communities, since the large amount of labor employed in operating these farms compels many workmen to live on each farm.

The white farmers, as far as possible, aim to live in town or to build in communities with their school or church near by. Thus, from their standpoint, the small farm located at a distance from these rural communities or from towns, partly or entirely surrounded by large plantations, is undesirable. Thus the problem of social relations has a vital effect on the organization of the farm community as a whole.

Naturally the underlying and most significant factor in bringing about the social and economic changes of the reconstruction period was the doing away with the system of labor in vogue before the war. Large areas that had formerly been farmed on the plantation system now became difficult to operate as farm units, and thus various systems of handling labor and of farm tenure came into vogue. The negroes were free to work as day laborers, or, where they owned or could borrow a little capital, they could become either tenants or small landowners.

In order to operate the owned farms under the changed conditions that have prevailed since the Civil War three distinct methods of employing labor have been inaugurated, namely, as wage hands, as share croppers, and as tenants.

The hiring of wage hands for the operation of the largest of these farms is a serious task, and it is the exceptional rather than the average man who is found operating a large farm with wage hands only. It is found to be about as profitable and less hazardous to engage not only wage hands but also share croppers and tenants in operating some of the larger farms. The scarcity of efficient labor willing to work for wages is the controlling factor in this regard.

Under the wage-hand system the laborers usually live on the farm and receive a specified cash wage. Rations may or may not be furnished.

The share cropper usually receives one-half of the crops for his labor and pays one-half of the fertilizer and ginning expenses, while the operator furnishes all the capital, pays all expenses other than those paid by the cropper, and has full supervision of the business. Because the share cropper does not furnish anything but labor he bears a close relation to the wage hand, the only difference being that he is paid a share of the crops for his services instead of cash wages.

In this study the croppers' share of crops, less the expense paid by them, has been used as a labor expense. The operator stands so much risk under this system that he is frequently subject to heavy loss unless he exercises close supervision. This share-cropper system is much more satisfactory to the negro than the wage system, not only because it gives him self-interest but because it also gives opportunity for the employment of his entire family. The more energtic and determined of these share croppers are soon able, by saving their money, to purchase a mule and machinery and become tenants.

In case of the tenant system the tenant furnishes all the working capital, and the landlord exercises very little supervision. His only concern is that the tenant raise enough cotton to pay the rent. This system of renting out a part of the farm and giving the tenant full control of its operation often does not work to the best welfare of the tenant. Many of these men will work regularly and efficiently only when directly under the supervision and control of the farm operator. Unless the tenant is proficient and uses good methods of management both in raising crops and in supervising labor, he is soon forced out of business and then necessarily has to start again as a wage hand and work up to the tenant stage. Where they realize and grasp the vast opportunities awaiting them these farmers are soon able to get enough money together to be fairly independent, but only a small percentage of them have the ability to operate farms upon their own responsibility and make a real success at the business.

Included in this study were 17 farms or plantations which were operated by managers hired to assume entire management and direction of the farm operations, just as the owner would. Eleven of these farms were in the white-owner, three in the white-owner-additional, and three in the white-owner-with-part-rented-out class. One of these manager farms had 135½ acres of crops, four had from 251 to 450 acres of crops, and the rest had over 450 acres in crops. When the salary of the manager is carried as operator's labor these farms are entirely comparable with other farms of the same tenure and size and have been included with them in all tables and discussions which follow.

In this area both white and colored operators are found under each form of tenure, but they have been shown separately in the tables and so treated in the discussion throughout this bulletin.

## TENURE AND SIZE OF FARM.

Of the total number of farms included in this study 317 were operated by white and 217 by colored farmers. Out of the 317 white farmers 50 per cent were straight owners, 12 per cent owners renting additional land, 22 per cent owners renting out a part of their land.

and 16 per cent tenants. Of the colored farmers 86 per cent were tenants, 6 per cent owners, 5 per cent owners renting additional land, and 3 per cent owners renting out a part of their farming land. (See Table II.)

One-sixth of the farms operated by white owners contained less than 50 acres of tilled land, one-half of them between 51 and 150 acres, and about one-third over 150 acres. About 1 out of every 15 of these farms contained over 450 acres of tilled land.

There were 38 farms operated by white owners additional, and 21, or more than one-half of them, had not over 100 acres of crops. However, about one-fifth of them had over 450 acres of crops, or a considerably higher proportion than of the owners.

The white-owner farms with part of the land rented out were the largest farms found in this area. Only about one-fifth of these farms have less than 100 acres of crops, nearly half of them over 250 acres, and about one-fourth over 450 acres.

Two-thirds of the white tenants had less than 100 acres of crops and only about one-tenth of them had over 150 acres. The largest farm of this tenure contained 323 acres of crops.

TABLE II.—*Relation of tenure to size of farm (534 farms, Sumter County, Ga.).*

| Tenure. | Number of farms under each specified area group. | | | | | | Total. |
|---|---|---|---|---|---|---|---|
| | 50 acres and less. | 51 to 100 acres. | 101 to 150 acres. | 151 to 250 acres. | 251 to 450 acres. | Over 450 acres. | |
| **White:** | | | | | | | |
| Owners | 25 | 41 | 40 | 31 | 12 | 11 | 160 |
| Owners, additional | 6 | 15 | 4 | 3 | 3 | 7 | 38 |
| Owners, with part rented out | 5 | 8 | 12 | 13 | 15 | 17 | 70 |
| Tenants | 17 | 17 | 10 | 3 | 2 | ........ | 49 |
| **Colored:** | | | | | | | |
| Owners | 1 | 7 | 3 | 1 | ........ | ........ | 12 |
| Owners, additional | 2 | 6 | 2 | 1 | ........ | ........ | 11 |
| Owners, with part rented out | ........ | ........ | 1 | 3 | 3 | 1 | 8 |
| Tenants | 96 | 68 | 18 | 4 | ........ | ........ | 186 |

There were but 12 colored-owner farms, and only 1 of these had over 150 tilled acres. These are comparatively small farms, two-thirds of them having less than 100 acres of crops.

The 11 farms of the colored-owners-additional class were distributed as to size practically the same as those of the colored owners. All the farms operated by colored owners with part of their land rented out had more than 100 acres of tilled land and one-half had over 250 acres

The colored tenants operate smaller farms than those of any other tenure. Ninety-six, or more than one-half of them, had less than 50 acres of tilled land. Eighty-eight per cent of these tenants farmed less than 100 acres and only 4 farms were found with over 150 acres of tilled land.

### RELATION OF TENURE TO DISTRIBUTION OF INVESTMENT.

In Table III is shown the distribution of the farm investment on farms operated under different forms of tenure. Land, buildings, live stock, machinery, feed and supplies, and cash represent the capital invested in the farming business.

The investment in land constitutes the greater part of the farm capital. The second item of investment of importance is the buildings. On the owner farms the house occupied by the operator is ordinarily a neat, well-built structure, but the tenants' houses are usually small and in many cases cheaply constructed and not kept in good repair. The cotton system of farming necessitates the support of a great amount of labor by each farm, making the investment in tenant houses a considerable item. The other farm buildings are of comparatively cheap construction and represent only a small share of the total investment. Outside of the owners renting additional land, the investment in land and buildings constitutes over 80 per cent of the total farm capital.

The item of investment third in importance in this area is that of work stock, which consists mostly of mules. This item's percentage of the total capital shows marked uniformity on both owner and tenant farms. The live-stock enterprise in this area, outside of the horses and mules necessary for farm work, is a very small item. The investment in other live stock represents the value of cows, hogs, and poultry, and is less than 2 per cent of the farm investment in all but one class of tenure. With the exception of three or four farms practically all the products from these three classes of live stock are used on the farm.

The investment in machinery represents only a small portion of total capital, since comparatively few expensive labor-saving machines are used. A large percentage of the farms use one-horse machinery in nearly all farm operations, which tends to bring the machinery investment to the minimum per farm. The percentage of investment in machinery runs more evenly on the white than on the colored operator farms. Undoubtedly the large factor other than that of type in limiting the use of labor-saving machinery here is the fact that it can not compete with hand labor at the present cost in this region.[1]

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[1] U. S. Dept. of Agr. Bulletin 338, Machinery Costs of Farm Operations.

**TABLE III**—*Relation of tenure to distribution of investment (534 farms, Sumter County, Ga.).*

| Distribution of investment. | White. | | | | Colored. | | | |
|---|---|---|---|---|---|---|---|---|
| | Owners. | Owners, additional.[a] | Owners, part rented out.[b] | Tenants (farm basis).[c] | Owners. | Owners, additional.[a] | Owners, part rented out.[b] | Tenants (farm basis).[c] |
| Number of farms | 160 | 38 | 70 | 49 | 12 | 11 | 8 | 186 |
| Total capital per farm | $13,773 | $10,521 | $26,883 | $5,685 | $5,984 | $3,043 | $15,998 | $3,210 |
| Per cent of total investment in: | | | | | | | | |
| Land | 65.1 | 53.7 | 71.6 | 68.8 | 72.4 | 63.3 | 75.0 | 77.0 |
| Houses | 6.8 | 6.9 | 4.5 | 7.8 | 5.8 | 3.6 | 5.9 | ........ |
| Tenant houses | 4.8 | 7.3 | 5.8 | 4.0 | 3.9 | 1.2 | 3.8 | 5.7 |
| Other buildings | 4.3 | 5.1 | 4.3 | 3.3 | 2.7 | 1.9 | 5.9 | 2.0 |
| Total land and buildings | 81.0 | 73.0 | 86.2 | [d] 83.9 | 84.8 | 70.0 | 90.6 | [d] 84.7 |
| Work stock | 7.3 | 10.1 | 5.5 | 7.4 | 6.8 | 14.4 | 5.3 | 7.4 |
| Other live stock | 1.3 | 1.3 | .7 | 1.6 | 1.3 | 3.1 | .5 | 1.4 |
| Machinery | 2.8 | 2.8 | 2.0 | 2.4 | 2.2 | 3.4 | 1.3 | 2.0 |
| Feed and supplies | 5.0 | 6.7 | 3.6 | 4.1 | 4.2 | 6.8 | 2.0 | 3.9 |
| Cash | 2.6 | 6.1 | 2.0 | .6 | .7 | 2.3 | .3 | .4 |

[a] Does not include investment in rented land.
[b] Includes the investment in land rented out.
[c] Landlord's and tenant's investment combined.
[d] Landlord's share of investment.

The investment in feed and supplies represents the inventory value of the feed and other supplies that were on hand at the beginning of the farm year. The item which makes the feed supplies investment seemingly of such importance is that for cotton seed, which some of the farmers each year hold over in abundance and use during the late spring for feed, seed, and fertilizing purposes.

Where farmers had cash of their own to run their farms during the year this item was carried as a part of the farm investment. Many of these farmers borrow all or a part of the money for the payment of their yearly expenses. The uneven distribution of the portion of the investment represented by this item is mostly explained by the fact that more money was borrowed for the payment of yearly operating expenses under some forms of tenure than under others. A much higher percentage of the white tenants and of all colored farmers borrow money for current operating expenses.

The farms operated by colored farmers show a higher percentage of total investment in land and lower in buildings than do the farms of white operators of the same tenure group.

The owners with additional rented land had a lower percentage of the total investment in land and a higher percentage in work stock than the men operating straight owner propositions. This additional investment in work stock is necessary in order to operate the extra land rented. In case of the owner with a part of his land rented out the proposition is exactly the reverse. His additional investment in land not operated by labor or equipment furnished by him will reduce his percentage investment in work stock.

### RELATION OF TENURE TO PROFITS.

The "farm income" is the difference between receipts and expenses; in other words, it represents the combined earnings of the capital and the operator's labor. The "labor income" represents the amount the farmer has left for his year's labor after deducting from the farm income 5 per cent interest on the capital invested. In addition to the farm income, each of these farmers has the benefit of house rent, wood for fuel, and what the farm furnishes toward the family living.

A serious defect in the system of farming followed by many farmers in this region is lack of attention to the production of home supplies. Failure to grow adequate forage and garden produce is, in general, a serious impediment to the advancement of an agricultural region. The long growing season gives these farmers almost unlimited opportunity for growing these products. The prosperity of the average farmer, especially the farmer with small means, depends in great measure upon the interest he takes in growing animal products, grains, fruit, truck, and garden vegetables for family use.[1]

In Table IV is given a comparison of the average tilled area, capital, receipts, expenses, farm income, and labor income for the different tenure groups.[2]

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[1] In an investigation made by the Office of Farm Management as to what the farm contributes directly toward the family living in Troup and Meriwether Counties, Ga. (U. S. Dept. of Agriculture, Farmers' Bulletin 635), the reports from 50 farms indicated that the average annual value of food, fuel, and house rent furnished by the home farm was $519.63 per family. Of this amount, $376.03 was for food products, such as meat, eggs, dairy products, grains, fruit, and vegetables. The value of these food products furnished by the farm represented 78.3 per cent of the total food expenses of these families. The annual value of fuel furnished by the farm was $51.60, and house rent amounted to $92. In carrying this study a little farther we find that the annual value of food, fuel, and house rent furnished by these farms was $96.25 per person. Of this amount, $69.25 was for food, $9.56 for fuel, and $17.04 for rent. While there is a wide variation in the standard of living among farmers in Sumter County, the above figures are of interest as indicating the value of the products the farm will afford without much cash expenditure in production. It can readily be seen from these figures that if it were not for those products contributed by the farm without much actual cash expenditure a great many farmers would not realize any savings from their labor income. In order to make the farmer's income comparable to the city man's wages the value of the above items should be added to the labor income.

[2] The interest rate here used is uniform with that used in all of the publications of the Office of Farm Management relating to farm-management surveys. However, after a study of the mortgage rates of interest paid in this area they are found to be 7.7 per cent upon farms of 150 or less tilled acres and 6.6 per cent upon farms of over 150 tilled acres. The average for all farms is 6.8 per cent. It may therefore be of interest in connection with this study to show what the labor income of the farms operated under different tenures would be if a rate of 7 per cent interest on the investment were deducted from the farm income instead of 5 per cent. Based upon a 7 per cent rate, the labor incomes are as follows:

*White operators.*—Owners, $577; owners additional, $1,062; owners with part rented out, $555; tenants, $529. *Colored operators.*—Owners, $268; owners additional, $478; owners with part rented out, $175; tenants, $302.

TABLE IV.—*Area, capital, receipts, expenses, and income on farms of different tenures. Sumter County, Ga.*

| | Number of farms. | Tilled area. | Capital. | Receipts. | Expenses. | Farm income. | Labor income. |
|---|---|---|---|---|---|---|---|
| White: | | *Acres.* | | | | | |
| Owners | 160 | 158 | $13,773 | $4,097 | $2,555 | $1,542 | $853 |
| Owners additional | 38 | 168 | 10,521 | 4,594 | 2,796 | 1,798 | 1,272 |
| Owners part rented out | 70 | 394 | 26,883 | 6,400 | 3,963 | 2,437 | 1,093 |
| Tenants | 49 | 85 | 890 | 1,572 | 980 | 592 | 547 |
| Colored: | | | | | | | |
| Owners | 12 | 95 | 5,984 | 1,659 | 977 | 682 | 383 |
| Owners additional | 11 | 77 | 3,043 | 1,646 | 955 | 691 | 539 |
| Owners part rented out | 8 | 307 | 15,998 | 3,107 | 1,812 | 1,295 | 495 |
| Tenants | 186 | 59 | 491 | 902 | 566 | 336 | 312 |

The 160 farms operated by white owners, having an average of 158 acres of tilled land and with an investment of $13,773, returned an average farm income of $1,542. Deducting interest on investment the owners have left, on the average, $853 as labor income. Deducting from the farm income the value of the farmer's labor, these farms show a return of 8 per cent on investment.

There were 38 farms operated by white owners renting additional land. On the average these men operated 168 acres of tilled land, but owing to 30 per cent of the farm area being rented, the average investment of these men was lower than that of the 160 owners. The average investment on these farms was $10,521, with a farm income of $1,798 and a labor income of $1,272. These men realized 12.6 per cent upon capital invested.

The 70 farms operated by white owners renting a part of their farming land out were the largest farms found in this study. These farms averaged 394 tilled acres, of which 41 per cent was rented out. The investment averaged $26,883, labor income $1,093, and interest on investment 7 per cent.

Forty-nine of the farms were operated by white tenants. These farms averaged 85 acres of tilled land, and with an average of $890 capital they returned a farm income of $592 and a labor income of $547. Several white tenants were found in this area who owned small farms, but who, in order to do a larger business, had leased their own farms and were operating large rented farms.

It will be noted from Table IV that in all classes of tenure the farms operated by colored farmers are smaller than those operated by white farmers of the same tenure.

Thirty-one of the farms were owned by colored farmers. Of this number 12 were operated as owner farms, with an average size of 95 illed acres; average investment was $5,984; farm income, $682; and abor income, $383. Eleven of the farms owned by colored farmers were operated with additional land rented. These farms averaged 77 tilled acres, of which 26 per cent was rented additional. They had an average capital of $3,043, a farm income of $691, and a labor income of $539.

The remaining 8 farms owned by colored farmers were operated as owners renting out part of their land. These farms averaged 307 acres of tilled land, of which 45 per cent was rented out. The average capital invested was $15,998, which returned them a farm income of $1,295 and a labor income of $495.

The 186 colored tenants, as previously stated, were operators responsible for the entire operation of the farm. They farmed on the average 59 acres, and with $491 capital realized a farm income of $336 and a labor income of $312. It is doubtful whether. on the average, these men make any higher profits than the share croppers, as under the share-cropper system the profits of the land owner are dependent upon the quality of the crops grown by the cropper. The most desirable feature of the tenant system, from the standpoint of the tenant, is that in the main he is emancipated from the directing authority of the landlord and thus has more liberty than the share cropper to do as he likes.

### THE FAMILY INCOME.

The family income is the amount of money available for the family living and the payment of interest on indebtedness after deducting cash expenses from total receipts. For the operators of small farms, and especially for most of the colored operators, this is the income of most concern to the family welfare.

The value of family labor per farm for the 268 white-owner farms was $43. This, when added to the farm income of $1,812, is of little concern to these farmers as a class. Indeed, many of these farms reported no family labor except that done by the operator.

Thirty-one of these farms, operated almost entirely by the farmer and his family, had on the average 36 acres of land devoted to crops. of which 16 acres were in cotton, 14 in corn, and the rest in other crops. Their average investment was $3,000, and all but 5 were free from mortgage. The families averaged 5 in number, with 2 under 16 years of age, and the value of family labor, besides that performed by the operator, averaged $220. With the aid of $28 worth of extra labor for picking cotton, these farmers realized an average family income of $551. This represents the amount of money available for the payment of living expenses, interest upon mortgage, and for savings. The largest families received the highest incomes. Three of these farms had 10 persons or more per family and made a family income of over $800 each.

An average of $55 worth of labor was performed by the families on the white-tenant farms. The average family income was $647. Twenty-one of the 49 white-tenant farms were operated by the tenant and his family. These farms averaged 38 tilled acres, of which 21 acres were in cotton, 13 in corn, and the rest in other crops. The average investment was $435. Six farms reported mortgages, averaging $100. The family labor was valued at $83, and with the aid of $37 extra labor they were enabled to make an average family income of $266 per farm. One-third of these families made less than $200 for the year. Only three made incomes as high as $400.

The average value of family labor on the 31 colored-owner farms was $198, while the average family income was $1,041. Ten of the colored-owner farms were operated almost entirely by the farm family. These averaged 69 tilled acres, with 41 acres in cotton, 20 in corn, and 8 in other crops. Investment averaged $3,500. Six farms out of the 10 were mortgaged. The family averaged 8, with 3 under 16 years of age, and the family labor was valued at $255. They hired $34 worth of additional labor. The family income was $853. Two of these families, each with 11 members, made over $1,000 each. Families averaging 3 or fewer made but little over $300.

The value of family labor per farm for the colored tenants was $168, and the average size of the family was 5. The family income on these farms was $504. In 140 out of the 186 tenant farms almost all the labor was performed by the negro family. These tenant farms averaged 47 tilled acres, with 30 acres in cotton, 13 acres in corn, and 4 acres in other crops. Average value of working capital was $366. One-half of these farmers reported mortgages to the amount of two-thirds of their capital. Families averaged 6, family labor $159, and family income $421. One-third of these family farms reported 8 persons or more per family and an average family income of $561.

Besides the income that these families are receiving, they have, as pointed out above, the meat and other animal products, fruits and vegetables, house rent, and fuel that are furnished by the farm. The value of these items that the farm furnish varies considerably, according to the standard of living each family maintains. From this study it is evident that this standard is much higher in some cases than in others. For example, the 31 white-owner families devoted an average of 20 acres to the growing of corn, small grains, potatoes, and other crops for farm and home use. One-half of these families raised and sold an average of $50 worth of such products over and above that needed for farm and home use. These farms reported the sale of such items as corn, oats, cowpea seed, peanuts, sweet potatoes, cane sirup, fruit, and garden products. Seven reported the sale of meat above that needed for home use, 10 sold eggs, and 7 sold butter or other milk products. When we consider that these families have an abundance of these products for home use, besides house rent and fuel, the family income of $551 they receive means much more than that sum earned by a city day laborer means to his family.

The white tenants used 17 acres for the growing of crops for home and farm use. Of these family farms, over 60 per cent sold crops besides cotton, including corn, sweet potatoes, Irish potatoes, peanuts, sirup, oats, watermelons, and garden vegetables, but the sales amounted to only $27 per farm reporting.

The colored owners used an average of 28 acres in growing crops for farm and home use. Only two reported sales from crops other than cotton, and this sale was for sirup and amounted to only $5 in each case. Two families sold eggs to the amount of $5 each.

The colored tenants used 17 acres for growing corn and other crops for farm and home use, but the yields most of these men received were very low. Of the 140 colored tenant family farms, 50 reported sales from crops other than cotton, but on 20 of the farms returns from these sales were less than $10. The average was $31 per farm reporting, the sales being mostly of watermelons, sirup, and sweet potatoes, with an occasional sale of corn, cowpeas, and other miscellaneous crops. It was observed during this study that many of the tenants evinced no pride whatever in keeping the house and surroundings neat and attractive. Few had a well-kept garden. Twenty-one of these family farms did not raise pork for home use. Land is always available for truck gardens, and it would be an easy matter for these tenants to raise most of their food products if they had the inclination, but it often happens that this land is either devoted to cotton and corn or left idle. The family income of these tenants is indeed very good. Where a tenant and his family with this small amount of capital can make $421 for their year's work, besides house rent and fuel and farm products, they are doing exceedingly well. But the part of this income these men should be able to save will be determined largely by the advantage they take of the opportunity of raising home products for family use. As the case is now, many farmers do a regular business of selling these tenants meat, grain crops, vegetables, and fruit.

### LANDLORDS' PROFITS.

The profits of the landlords in this region vary considerably from year to year. With but two exceptions, the landlords rented their farms in this region for a specified amount of the cotton, and the profits they received depended directly upon the price they received for the cotton. Ordinarily the rent is on the basis of the number of mules necessary in operating the farm. The rent ranges from 2 to 3 bales per mule.

The landlords renting to white tenants had an average investment of $4,795 per tenant, and made a profit of 7.3 per cent. One landlord rented for cash and received 5 per cent upon his investment.

The average investment of the landlords renting to colored tenants was $2,719 per tenant, and they made a profit of 8.9 per cent. One of these farms was rented for cash and returned the landlord 4 per cent.

The profits that landlords realize on many of these farms are not comparable with the incomes of landlords in the Northern States. More or less supervision is given many of these tenants. The landlord in many cases gives security for tenants' credit or gives orders on stores for provisions and other supplies, settling with the tenants when the cotton is sold. Where no supervision is exercised by the landlord, the land worked by many of these tenants becomes more or less impoverished.

### THE RELATION OF TENURE TO FARM LOANS AND INTEREST RATES.

It is an old and well-established custom in this region for farmers to borrow money for carrying on their business during the year. There are many ways of handling this loan, but the method quite generally used is that in which the farmer goes to the bank at the beginning of the year, places his order for the season's loan, and draws it out as needed. This yearly loan is considered entirely separate from the mortgage loan which some of them carry. The mortgage loan refers to real estate indebtedness or to debts carried over from previous years. In Table V is shown the average amount of yearly loan and interest rates paid on farms operated under different forms of tenure.

Out of the 268 white owners, 60 per cent reported borrowing money for carrying on their year's business. They borrowed on the average $940 each, at an average rate of 7 per cent. The men on farms of 150 or fewer tilled acres were paying 7.8 per cent, while the men on the larger farms paid 6.8 per cent. Undoubtedly the higher interest rates paid on the small farms were largely due to the small amounts borrowed. The men on the smaller farms only borrowed an average of $286 per year to meet their expenses, while the larger farmers borrowed $1,635. The small farmer evidently is just as safe, as only 33 per cent of them reported a farm mortgage, whereas 44 per cent of the larger farms were mortgaged. On the average the smaller farms had a mortgage of $1,488 and paid 7.7 per cent interest. The larger farmers borrowed an average of $8,623 and paid 6.6 per cent interest.

Of the white tenants, 84 per cent borrowed money for expenses. These men borrowed an average of $309 per year and paid 8.8 per cent interest. Over one-fourth (26 per cent) reported mortgages, averaging $353, with interest charges averaging 9.1 per cent. This mortgage represents 57 per cent of the total capital owned by these men. The amount these men borrow does not have so much influence upon the interest rate they pay as in case of the farm owners. The risk is much greater in making loans to men who own no real estate.

The yearly loan was practiced by 94 per cent of the colored owners. These men paid somewhat higher rates of interest than the white owners, but the white owners borrowed three times as much per farm as did the colored owners. Of the latter, those in the smaller-size group borrowed $206 each and paid 10.3 per cent, while on the larger farms they borrowed $596 each and paid interest at the rate of 9.4 per cent. Data regarding the farm mortgages of these colored owners were not complete enough to be included in this table. On the average for all the owner farms the interest rate is about 1 per cent cheaper on the larger farms than on the farms of the smaller-size group.

All but 6 of the colored tenants carried their yearly farm expenses on borrowed money. In many cases this money was either borrowed by the landlord and given out in small quantities to them or else he stood good for their loan. They borrowed an average of $153 apiece and paid interest at the rate of 10.6 per cent. Data were not complete regarding the number of these tenants carrying a mortgage on their working capital, but for those reporting, the average capital was $476, the mortgage $284, and the interest rate 10.5 per cent. Money loaned under these circumstances involves great risk, and consequently the interest rate is correspondingly high.

TABLE V.—*Relation of tenure to farm loans and interest rates (Sumter County, Ga.).*

| Tenure. | Farms of 150 tilled acres or fewer in size. | | | Farms over 150 tilled acres in size. | | | All farms. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Per cent of farms reporting. | Amount of loan. | Interest rate. | Per cent of farms reporting. | Amount of loan. | Interest rate. | Per cent of farms reporting. | Amount of loan. | Interest rate. |
| 268 white-owner farms: | | | *Per ct.* | | | *Per ct.* | | | *Per ct.* |
| Yearly loan | 53 | $286 | 7.8 | 70 | $1,635 | 6.8 | 60 | $949 | [illegible] |
| Mortgage loan | 33 | 1,488 | 7.7 | 44 | 8,623 | 6.6 | 38 | 4,949 | [illegible] |
| 49 white tenants: | | | | | | | | | |
| Yearly loan | 82 | 228 | 8.9 | 100 | 890 | 8.7 | 84 | 309 | [illegible] |
| Mortgage loan | 27 | 265 | 8.8 | (a) | ........ | ........ | 26 | 353 | [illegible] |
| 31 colored owners: | | | | | | | | | |
| Yearly loan | 96 | 206 | 10.3 | 89 | 596 | 9.4 | 94 | 313 | [illegible] |
| 186 colored tenants: | | | | | | | | | |
| Yearly loan | 97 | 145 | 10.6 | 75 | 633 | 10.6 | 97 | 153 | [illegible] |

[a] Only one farm reporting.

### THE RELATION OF TENURE AND CAPITAL TO PROFITS.

In Table VI the white owners, owners additional, and tenants are classified into groups based upon the amount of capital invested and showing the number of acres tilled and labor income in each group. It is possible, with the present price of labor, to grow cotton profitably with a very inexpensive equipment, and hence one may begin cotton farming with a small amount of capital. This table shows clearly that the man desiring to farm with a small amount of capital has the best opportunity as a tenant. The second best proposition is that of owning a farm and renting additional land for raising crops. The straight owner proposition is third. The reason the owner who rents additional land is making somewhat higher profits than the straight owner with the same capital is that he is able thereby to operate a greater acreage with a given amount of capital. Unless a farmer has a large amount of capital to invest, owning land and renting out a part of it is not desirable.

**Table VI.**—*The relation of tenure and capital to labor income on 247 farms operated by white owners, owners additional, and tenants, Sumter County, Ga.*

| Operator's capital. | Average number of tilled acres and average labor income in each specified tenure. | | | | | |
|---|---|---|---|---|---|---|
| | Owners (160 farms). | | Owners additional (38 farms). | | Tenants (49 farms). | |
| | Tilled area. | Labor income. | Tilled area. | Labor income. | Tilled area. | Labor income. |
| $500 and less | ......... | ......... | ......... | ......... | 39 | 170 |
| $501 to $1,000 | ......... | ......... | ......... | ......... | 70 | 460 |
| $1,001 to $2,000 | 25 | 139 | 40 | 250 | 137 | 928 |
| $2,001 to $3,000 | 45 | 122 | 67 | 529 | 259 | 1,509 |
| $3,001 to $5,000 | 62 | 329 | 93 | 717 | 323 | 2,725 |
| $5,001 to $9,000 | 94 | 515 | 132 | 987 | ......... | ......... |
| $9,001 to $14,000 | 139 | 736 | 264 | 964 | ......... | ......... |
| $14,001 to $25,000 | 177 | 1,132 | 303 | 3,240 | ......... | ......... |
| Over $25,000 | 440 | 2,293 | 725 | 3,948 | ......... | ......... |

The tenant farmer with about $1,000 capital has the use of 70 acres of tilled land, and, as compared with the hired man's wages in this region, makes a very good labor income. In order to operate this much land as an owner renting additional land, which the data shows is the second best proposition, he would need three times as much capital. To operate the same amount of land as a straight owner he would require five times as much capital.

The tenant operating a farm business representing an investment of between $1,000 and $2,000 has the use of considerably over 100 acres of tilled land, while in order to operate this much land as an owner renting additional land he would require over $5,000 capital, and as a straight owner over $9,000. The largest farm operated by a white tenant contained 323 tilled acres. With $4,820 capital this man received a labor income of $2,725. In order to have operated a farm of this size as an owner additional he would have needed $21,000 capital and as a straight owner over $25,000.[1]

The relation of capital to profit indicated in Table VI holds true in other regions where studies of this nature have been carried on. The men with the most capital are, as a rule, making the highest labor incomes. This, however, does not mean that all the men with a large amount of capital are making large labor incomes. More capital gives additional chances for a larger volume of business, but unless the quality and efficiency of this business is up to the normal, the less business a man does the less he is liable to lose.

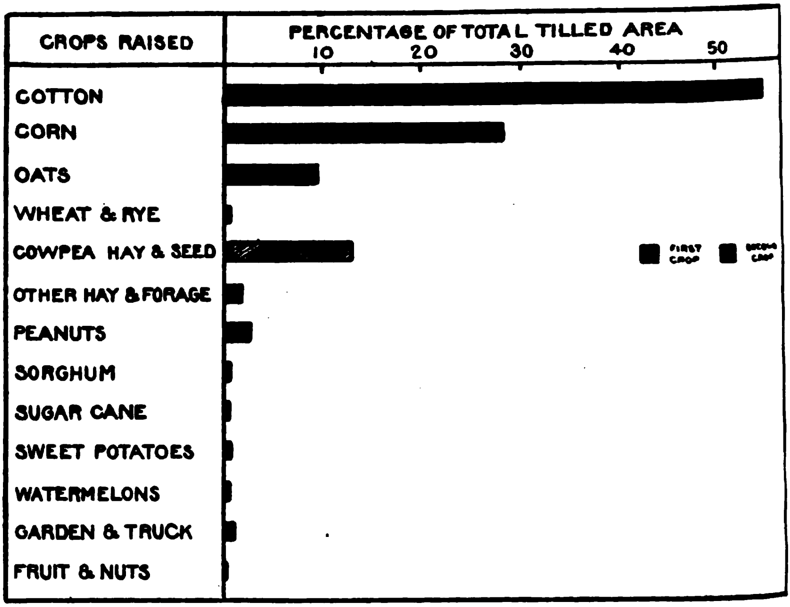

FIG. 4.—Proportion of tilled area devoted to different crops (160 white-owner farms Sumter County, Ga.).

### RELATION OF TENURE TO DISTRIBUTION OF CROP AREA.

The long growing season, together with other favorable conditions enables the farmers of this area to grow a large variety of crops and in many cases to use the land for more than one crop during the year. The length of the growing season for the year 1913 was 207 days. The crops are raised under the wage-hand and share-cropper system of handling labor. Under the wage-hand system all the labor is per formed by wage hands. Under the share-cropper system a share of the crops is given for the labor, while the operator furnishes the land, equipment, work stock, pays part of the expenses, and supervises the work.

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[1] The tenant is at a disadvantage if farming in a region where the land is increasing in value. If the land is increasing or likely to increase in value a tenant would be better off to invest what capital he is able to secure in land, even though the size of his business and profits are lower than as a tenant. In computing the labor income the increase in land value is not taken into consideration.

Table VII shows for each class of tenure the percentage of crop land devoted to each crop when grown as a first crop and as a second crop. The accompanying chart (fig. 4) presents graphically the percentage distribution of crop area on the 160 white-owner farms. Under the present organization of these farms cotton is the crop of far greatest importance. It is well adapted to this region and does well on both clay and sandy soils. It occupies 59 per cent of the crop area of the region. This crop is handled by both wage and share croppers, but the proportion of the cotton area operated under these two systems varies under the different classes of tenure. In case of the colored owners and colored tenants a very small proportion of the area is farmed under the share-cropper system. The three classes of white owners have about 57 per cent of their crop area devoted to cotton, while the white tenants have over 63 per cent. Both colored owners and colored tenants have a higher percentage of their crop area in cotton than do the white operators.

TABLE VII.—*Relation of tenure to distribution of crop area (534 farms, Sumter County, Ga.).*

| Crops. | White operators. | | | | Colored operators. | | | |
|---|---|---|---|---|---|---|---|---|
| | Owners. | Owners, additional. | Owners, part rented out. | Tenants. | Owners. | Owners, additional. | Owners, part rented out. | Tenants. |
| Number of farms | 160 | 38 | 70 | 49 | 12 | 11 | 8 | 186 |
| Percentage of tilled area in— | | | | | | | | |
| Wage cotton | 21.7 | 22.4 | 23.8 | 40.5 | 52.0 | 46.0 | 29.0 | 58.2 |
| Share-cropper cotton | 34.9 | 35.0 | 33.1 | 22.8 | 7.8 | 17.5 | 33.1 | 7.3 |
| Total cotton | 56.6 | 57.4 | 56.9 | 63.3 | 59.8 | 63.5 | 62.1 | 65.5 |
| Wage corn | 15 | 16.7 | 15.1 | 20.4 | 26.1 | 21.4 | 13.7 | 24.5 |
| Share cropper corn | 13.5 | 13.5 | 11.3 | 5.9 | 4.3 | 4.8 | 17.3 | 2.4 |
| Total corn | 28.5 | 30.2 | 26.4 | 26.3 | 30.4 | 26.2 | 31.0 | 26.9 |
| Oats for grain | 9.4 | 7.5 | 10.2 | 5.4 | 4.0 | 4.2 | 2.2 | 2.7 |
| Wheat and rye | .4 | .3 | .5 | .1 | .3 | ........ | ........ | (a) |
| Cowpea hay and seed | .6 | .4 | 2.0 | .3 | (a) | 1.7 | ........ | .6 |
| Second crop | 12.3 | 10.5 | 7.7 | 8.3 | 12.4 | 9.7 | 11.4 | 5.7 |
| Other hay and forage | 1.1 | 1.2 | 1.2 | 1.6 | 2.9 | .9 | 3.2 | 2.0 |
| Second crop | .7 | 1.0 | .9 | 1.5 | 2.4 | ........ | .7 | .8 |
| Peanuts | 1.3 | 1.1 | .9 | 1.3 | .7 | 1.1 | .3 | .4 |
| Second crop | 1.3 | 1.2 | .4 | .5 | 1.0 | ........ | .4 | ........ |
| Sorghum | .3 | .3 | .3 | .2 | .1 | .1 | .1 | .2 |
| Sugar cane | .3 | .3 | .2 | .2 | .4 | .7 | .2 | .4 |
| Sweet potatoes | .4 | .4 | .3 | .5 | .4 | .6 | .6 | .5 |
| Watermelons | .3 | .1 | .1 | .1 | .1 | .4 | .1 | .3 |
| Garden, truck, etc | .7 | .7 | 1.0 | .7 | .9 | .6 | .3 | .5 |
| Fruits and nuts | .1 | .1 | (a) | (a) | ........ | ........ | ........ | ........ |
| Total per cent of crop area used for second crop | 14.3 | 12.7 | 9.0 | 10.3 | 15.8 | 9.7 | 12.5 | 6.5 |

[a] Less than one-tenth of 1 per cent.

Corn, the crop second in importance in this region, is grown by practically every farmer and occupies over one-fourth of the tilled area. Corn and fodder constitute the principal feed for live stock. Corn is also quite generally used as a family food. The area devoted to this crop in the different classes of tenure ranges from 26.3 to 31 per cent of the total tilled area. As a rule the owners are devoting more attention to raising corn than are the tenants.

The small-grain crops are third in importance in utilizing the land for first crops. Oats are the principal small-grain crop grown in this region, and are also of much importance as a hay and pasture crop. They are well adapted to a wide range of soils and can be harvested early enough in the summer to utilize the land for other crops which may be harvested the same season. Much of the oats harvested as a grain crop is fed in the sheaf. As a grain crop oats occupy from 7 to 10 per cent of the crop area on white-owner farms, 5 per cent upon the white-tenant farms, and 4 per cent or less upon the farms with colored operators. Wheat is grown on a small number of farms in this area and returns only fair yields. While only a few farms grow rye as a grain crop, it is used more extensively as a cover and green-manuring crop. In regions north of this county these two crops occupy a larger acreage and give much higher yields.

Cowpeas occupy an important place in the agriculture of this region. As this plant is of tropical origin, it grows well during hot weather, completing its growth in from 3 to 4 months and thereby making it possible to grow it at times when the land would otherwise be idle. Cowpeas are not only valuable as a hay and seed crop, but have a high soil-fertility value as well. The area devoted to this crop for hay and seed is shown in Table VII. There were, in addition, certain farms where cowpeas were sown and plowed under during the year for their fertilizing value, but complete records of the acreage treated in this manner were not secured. The cowpea is the crop of greatest importance in the utilization of land for the second time during the year. It occupies only a small percentage of the first-crop area, but as a second crop it utilizes as high as 12 per cent of the tilled area on some tenures. The usual practice in this region is to follow grain crops, usually oats, with cowpeas for hay. On corn ground cowpeas are usually sown during the last cultivation. When this can be done the cost, above that for seed, is very small. After harvesting the cowpea seed the vines are left on the ground for pasture or to be plowed under.

There are a number of other crops used for hay, but the areas of these are of such minor importance that they are grouped together as "other hay." Oats occupy the most important place in this respect, while rye, peanuts, sorghum, vetch, Bermuda grass, meadow hay, beggarweed, or crab grass were reported in small scattering areas.

The portion of the crop area devoted to these crops is fairly evenly divided between first and second crop land.

Few farmers in this region grow peanuts as a money crop. Only enough seed is harvested for farm use; the rest of the crop is used as feed for hogs, the hogs doing the harvesting. Peanuts give very satisfactory returns as a feed and can be grown as a second crop during the year. Less than 2 per cent of the crop area is devoted to peanuts.

Saccharine or sweet sorghum is used mainly as a forage crop. It returns very satisfactory yields and a number of the farmers devote small areas to it.

Sugar cane, sweet potatoes, and watermelons are raised mainly for farm and home use and occupy about 1 per cent of the crop area.

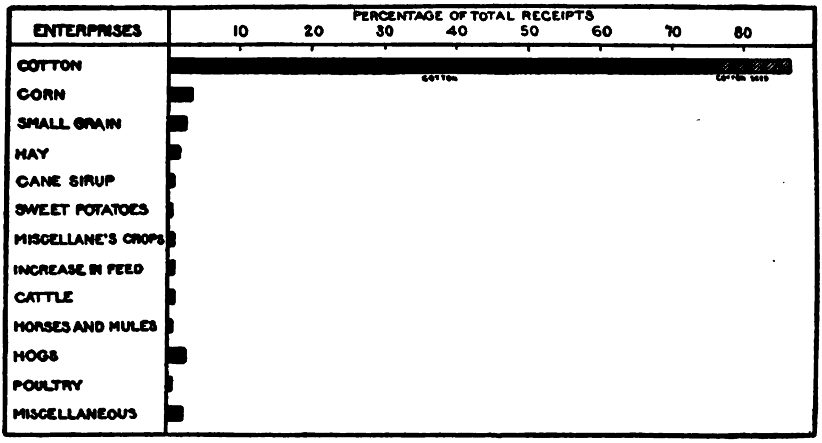

FIG. 5.—Proportion of farm receipts from different sources (160 white-owner farms, Sumter County, Ga.).

Many of these farms have an area devoted to growing garden vegetables and truck crops for use in the home and supplying hired labor. The large amount of labor maintained on these farms makes the growing of these crops quite essential.

The owners devote a larger portion of the crop area to raising farm feeds and home supplies than do the tenants.

### THE RELATION OF TENURE TO DISTRIBUTION OF FARM RECEIPTS.

In Table VIII is shown the distribution of receipts on farms operated under the different classes of tenure. Figure 5 represents graphically the percentage of distribution of farm receipts on the white-owner farms.

This table brings out clearly the importance of the cotton enterprise in this region. On the farms worked by white operators the receipts from cotton and seed alone range from 86.4 to 89.8 per cent of the total for each tenure. In case of the farms worked by colored operators, even a larger amount of the farm receipts comes from the sale of cotton, the range averaging from 87.5 to 94.2 per cent of the total receipts.

Practically all the corn crop is required for feed and family use. A large portion of it is used for feeding work stock and the large number of hogs kept.

While Table VII shows that the colored operators devote about the same proportion of area to corn as do the white operators, the former received much lower yields and consequently were not able to sell nearly as large a portion of the crop. For the entire area the receipts from corn are less than 3 per cent of the total farm receipts.

TABLE VIII.—*The relation of tenure to distribution of farm receipts, Sumter County, Ga.*

| Source of income. | White operators. | | | | Colored operators. | | | |
|---|---|---|---|---|---|---|---|---|
| | Owners (160 farms). | Owners, additional (38 farms)[c]. | Owners, part rented out (70 farms)[d]. | Tenant (farm basis) (49 farms)[e]. | Owners (12 farms). | Owners, additional (11 farms)[c]. | Owners, part rented out (8 farms)[d]. | Tenant (farm basis) (186 farms)[e]. |
| Percentage of income from— | | | | | | | | |
| Cotton | 75.4 | 75.8 | 79.3 | 76.8 | 81.7 | 78.4 | 81.0 | 82.8 |
| Cotton seed | 11.0 | 11.0 | 10.5 | 12.1 | 9.4 | 9.1 | 7.3 | 11.4 |
| Total cotton | 86.4 | 86.8 | 89.8 | 88.9 | 91.1 | 87.5 | 88.3 | 94.2 |
| Corn | 3.4 | 3.3 | 2.1 | 2.2 | 1.1 | .5 | 3.8 | .6 |
| Grain crops | 1.2 | 1.1 | .4 | .6 | ........ | ........ | ........ | ........ |
| Cow pea hay | .7 | .6 | .2 | .5 | (a) | .2 | ........ | (a) |
| Other hay and forage | (a) | ........ | (a) | ........ | ........ | ........ | ........ | ........ |
| Cane sirup | .6 | .4 | .4 | .4 | .2 | .9 | .2 | .2 |
| Sweet potatoes | .3 | .4 | .1 | .3 | .1 | .3 | .1 | .3 |
| Fruit and nuts | (a) | .1 | .1 | (a) | ........ | ........ | ........ | (a) |
| Miscellaneous crops | .6 | .1 | (a) | .2 | .3 | .2 | .5 | .2 |
| Total crops | 93.2 | 92.8 | 93.1 | 93.1 | 92.8 | 89.6 | 92.9 | 95.5 |
| Increase in feed and supplies | .9 | 1.9 | 2.2 | 3.3 | 3.9 | 4.6 | .6 | 2.4 |
| Cattle[b] | .8 | .4 | .6 | .6 | .7 | 1.7 | .4 | .5 |
| Horses and mules | .2 | .2 | (a) | .1 | ........ | .2 | ........ | ........ |
| Hogs | 2.3 | 1.3 | .9 | .6 | (a) | (a) | .2 | (a) |
| Poultry | .5 | .2 | .2 | .5 | .3 | .3 | .2 | .3 |
| Bees | (a) | (a) | ........ | (a) | (a) | ........ | ........ | (a) |
| Total stock | 3.8 | 2.1 | 1.7 | 1.8 | 1.0 | 2.2 | .8 | .8 |
| Miscellaneous sources | 2.1 | 3.2 | 3.0 | 1.8 | 2.3 | 3.6 | 5.7 | 1.3 |

[a] Less than one-tenth of 1 per cent.
[b] Two farms reported goats.
[c] Does not include the landlord's receipt on additional land rented.
[d] Includes owner's receipts on part of farm rented out.
[e] Landlord's and tenant's receipts combined.

The other crop sales are of only very minor importance and consist of grain, hay, sirup, sweet potatoes, watermelons, and other crops, including some fruit and a few garden products. The sale from these items is relatively higher upon the white-operator than upon the colored-operator farms.

The item of feed and supplies is only a small receipt and represents the increase in value of feeds and other supplies on hand at the end of the year above that on hand at the beginning of the year.

The receipt from live stock and live-stock products in this area is a very small item. Very little attention is given the live-stock industry. Aside from the mules, usually only enough cows, hogs, and poultry are kept for farm use. With the present yields it requires practically all the crop land above that devoted to cotton for supplying the needs of farm and family in carrying on the business.

Hogs are the most important live-stock enterprise. Besides supplying farm needs, they return more than any other class of stock. So many laborers are required for the operation of these farms that a large number of hogs are slaughtered each year for supplying them.

The other live-stock receipts are from the sale of dairy products, cattle, horses, mules, colts, and poultry, and on most of the tenures constitute about 1 per cent of the total farm receipts.

The receipts from miscellaneous sources return these farms a small income each year. These miscellaneous receipts include such items as returns for labor done outside the farm, for wood sold, and for cotton ginning, and rent of land or buildings.

### THE RELATION OF TENURE TO DISTRIBUTION OF FARM EXPENSES.

In Table IX is given the percentage distribution of the more important items of expense. Almost all the labor in this region is performed by the colored man and his family. The wage hand is paid from $10 to $18 per month and rations. It is the general custom to issue the rations to the laborers by the week or month. Some of these rations are purchased and the operator usually attends to the buying of these provisions and issues them to the hands. Rations are furnished wage hands and advanced to croppers. Some of the larger farms maintain commissaries or stores, which give the owner the advantage of buying by wholesale. Labor is generally employed by the year in order to have it at times when most needed. In many cases it is necessary to advance wages. Practically all labor is contracted for during the latter part of December or at the first of the year.

The first four items of expense shown in Table IX include the entire expenditure for labor other than that done by the operator, namely, expenses for wage hands, for extra labor for "chopping" and picking cotton, cropper's share of crops, and the value of the labor performed by the operator's family. In case of the white farmers, over one-half of the labor expense is paid to share croppers and their families. On the colored farms a much higher percentage of the labor is performed by members of the family. The variation in the expense for labor is from 41 per cent to 56 per cent of the total farm expenditures in the various tenure classes. The expense for repairs of machinery and buildings is greater upon the white operators' farms, but the expense for fence repairs and terraces is about the same in all classes of tenure. The time and expense put upon fences or terraces represents in all cases only what was necessary. The fundamental reason for the difference in the upkeep of buildings, and especially the dwellings, is that the occupant of the tenant house is not the owner and neither the landlord nor the tenant has the interest in the property that the owner occupant has.

TABLE IX.—*Relation of tenure to distribution of farm expenses (534 farms, Sumter County, Ga.).*

| Items of expense. | White operators. | | | | Colored operators. | | | |
|---|---|---|---|---|---|---|---|---|
| | Owners (160 farms). | Owners additional (38 farms).[b] | Owners part rented out (70 farms).[c] | Tenants (farm basis) (49 farms).[d] | Owners (12 farms). | Owners additional (11 farms).[b] | Owners part rented out (8 farms).[c] | Tenants (farm basis) (186 farms).[d] |
| Percentage of total expense represented by— | | | | | | | | |
| Wage hands | 12.4 | 10.4 | 16.8 | 10.2 | 4.9 | 5.4 | 9.9 | 4.4 |
| Cotton picking and chopping (extra labor) | 6.9 | 6.8 | 6.7 | 8.6 | 9.6 | 4.0 | 6.5 | 4.8 |
| Share croppers | 34.4 | 29.3 | 29.0 | 24.9 | 9.3 | 17.7 | 26.8 | 8.2 |
| Family labor | 2.0 | 2.3 | .7 | 5.5 | 28.3 | 14.3 | 9.0 | 28.6 |
| Total labor | 55.7 | 48.8 | 53.2 | 49.2 | 52.1 | 41.4 | 52.2 | 46.0 |
| Repairs— | | | | | | | | |
| Machinery | 1.4 | 1.7 | 1.7 | .9 | .8 | .7 | 1.9 | .8 |
| Buildings | 2.4 | 2.8 | 4.0 | 1.4 | .4 | .7 | 3.4 | .7 |
| Fences | .5 | .3 | .4 | .3 | .5 | .3 | .2 | .5 |
| Terracing | .3 | .1 | .2 | .2 | .1 | .3 | ........ | .2 |
| Feed, hay, etc | .5 | .6 | .9 | 1.2 | 1.0 | .6 | .8 | 1.7 |
| Feed, grain, etc | 1.8 | 1.5 | 2.1 | 3.9 | 4.6 | 2.5 | 2.2 | 4.6 |
| Horseshoeing | .2 | .2 | .2 | .2 | .2 | .2 | .3 | .2 |
| Breeding fees and veterinary | .2 | .1 | .2 | .3 | ........ | .1 | .2 | .1 |
| Seeds and plants | .9 | .9 | 1.4 | 1.5 | 1.0 | .5 | 1.2 | 1.1 |
| Fertilizer— | | | | | | | | |
| Croppers | 13.2 | 12.7 | 11.5 | 9.1 | 3.9 | 9.4 | 12.2 | 3.5 |
| Wage land | 13.9 | 12.1 | 12.5 | 19.4 | 22.6 | 17.7 | 9.5 | 26.2 |
| Thrashing and twine | .3 | .3 | .1 | .2 | ........ | ........ | ........ | (a) |
| Ginning, bags, and ties | 4.6 | 4.6 | 4.0 | 6.3 | 6.1 | 6.2 | 8.0 | 7.2 |
| Machine hire, fuel, and oil | .2 | .3 | .6 | .1 | (a) | (a) | ........ | .1 |
| Insurance | .3 | .7 | .5 | .2 | ........ | ........ | ........ | .1 |
| Taxes | 2.3 | 2.3 | 3.8 | 3.0 | 3.8 | 2.2 | 4.4 | 3.6 |
| Interest on loan | .8 | 1.4 | 2.1 | 2.2 | 2.9 | 1.8 | 2.6 | 2.7 |
| Mule hire | ........ | ........ | ........ | .3 | ........ | ........ | ........ | .7 |
| Cash rent | ........ | 7.9 | ........ | ........ | ........ | 14.2 | ........ | ........ |
| Miscellaneous | .5 | .7 | .6 | .1 | ........ | 1.2 | .9 | (a) |

[a] Less than one-tenth of 1 per cent.
[b] Does not include landlord's expense on additional land rented.
[c] Includes expenses on part of land rented out.
[d] Landlord's and tenant's expenses combined.

The expense for feed purchased, such as hay, fodder, grain, and concentrates, is much higher upon the farms operated by colored farmers. In other tables it is shown that much of their additional expense is due to the very low yields of crops they receive. In case of the white farmers the expense for feed ranges from 2.1 per cent for the owners renting additional land to 5.1 per cent for the tenants. For the colored operators this item of expense ranges from 3 per cent for the owners with part rented out to 6.3 per cent for the tenants. In a study and comparison of these farms it is evident that the colored farmers provide a smaller proportion of farm feed for their stock and garden products for their family. Wage hands and share croppers generally depend upon the farm operator to supply them with these latter products.

The expense for fertilizer is of much concern to these farmers, as this item embraces one-fourth or more of the farm expenses. The share croppers are held responsible for their share of this expense for fertilizer shown under share-cropper fertilizer. On both the white-tenant and colored-tenant farms, the percentage of total farm expenditures for fertilizer is higher than on the owner farms. This does not mean that these men use more or better fertilizer than the owners, but that the greater number of them buy in small quantities and ready mixed. The owners in many cases buy fertilizing materials and do the mixing at home, and many of them buy in large quantities. The cash expense for cotton ginning runs much higher on the farms operated by white tenants and all colored operators. This is due mainly to the fact that nearly all the cotton gins are on the white-owner farms. The interest and depreciation charges upon these gins are not considered in these expenses.

The proportion of expenses required for taxes is, on the average, about 3 per cent, varying somewhat in the different tenures. The item of interest paid upon money borrowed for the payment of the year's operating expenses is only a small item when compared with the expenses of the farm as a whole. This expense is a little higher upon the white-tenant farms and on all the farms operated by colored farmers, but is below 3 per cent of the total in all classes. The expense for the hire of mules is an item of much concern to some of these tenants, both white and colored. Five of the white tenants and 23 of the colored tenants hired mules. The charge for the use of these mules during the year is very reasonable, being, with few exceptions, $25 per mule. These mules were usually owned by the landlord. The expense for rent of land was 7.9 per cent upon the white-owner-additional farms and 14.2 per cent on the colored-owner-additional farms. Labor and fertilizer constitute three-fourths of the expenses on these farms.

### RELATION OF TENURE TO THE PERCENTAGE OF RECEIPTS REQUIRED FOR OPERATING EXPENSES.

In Table X is shown the average receipts and expenses and the percentage of receipts required for cash expenses in the different classes of tenure. This table shows why the chance of heavy loss is so great in straight cotton farming. The fact that this crop occupies such a large portion of the crop area and involves such a heavy outlay of money for production makes heavy loss certain when yield or price is low. With the cash expenses 60 per cent of the receipts it can readily be seen that if for any reason these receipts should drop 40 per cent there would be little if any income left for interest on investment and to pay for the farmer's labor. The raising of an abundance of farm feed and of garden supplies is of exceedingly great value in tiding these farmers over occasional years of low returns, such as are inevitable under the present type of farming. Where a man has but one cash crop a failure is a serious matter, since he is thus forced to carry all of his expenses for another year.

The average receipts and expenses on these farms are some indication of the size of business they are doing. Both the white owners and white owners additional have receipts averaging above $4,000 per farm, while the owners with part rented out have, on the average, $6,400 receipts per farm. The average receipts on 378 farms operated by owners in Chester County, Pa., were $2,312 per farm.[1] In the case of the farms operated by white farmers about 62 per cent of the receipts on the owner farms are required for expenses. The white tenants show a lower expense when figured upon this basis, it being 52 per cent of the farm receipts. The colored operators show a lower percentage of the receipts required for expenses, averaging about 58 per cent upon the owner and 51 per cent upon the tenant farms.

The percentage cash expenses of the total receipts are naturally lower upon the smaller farms, as the operator does the work of a farm hand, while on the large plantations his time is entirely taken up in supervising the work. On the tenant farms the value of the work done by the operator was 16 per cent of the receipts, while with the owners, where a larger business is done, it averaged 10 per cent upon the white and 13 per cent upon the colored farms. This accounts for the fact that the expenses of the white tenants and of all the colored operators as compared with receipts are relatively low.

TABLE X.—*Relation of tenure to percentage of receipts required for operating expenses (Sumter County, Ga.).*

| | White operators. | | | | Colored operators. | | | |
|---|---|---|---|---|---|---|---|---|
| | Owners. | Owners (additional). | Owners (part rented out). | Tenants (farm basis).[2] | Owners. | Owners (additional). | Owners (part rented out). | Tenants (farm basis).[2] |
| Number of farms | 160 | 38 | 70 | 49 | 12 | 11 | 8 | 186 |
| Average total receipts | $4,097 | $4,594 | $6,400 | $1.953 | $1,659 | $1,646 | $3,107 | $1,165 |
| Average total expenses | $2,555 | $2,796 | $3,963 | $1,023 | $977 | $955 | $1,812 | $599 |
| Average percentage of receipts required for operating expenses | 62 | 61 | 62 | 52 | 59 | 58 | 58 | 51 |

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[1] U. S. Department of Agriculture Bulletin 341.
[2] Landlord and tenant receipts and expenses combined.

### RELATION OF TENURE TO YIELD PER ACRE.

Table XI shows the average yields of the more important crops grown in this region for each class of tenure, and for each race. This table indicates the possibilities of increasing profits by getting higher yields. The yield of cotton and of corn grown on the land worked by wage-hand and share-cropper labor is shown separately. As a rule the land worked by wage hands seems to return the highest yields. However, this increase in yield can not be due to the superior efficiency of the wage hand over the share cropper, for, as a rule, the latter is the more industrious laborer. The three more vital factors influencing the production of the higher yields on land worked by wage-hand labor are: First, closer supervision by the operator or manager; second, the land worked by wage hands usually includes the most fertile land on the farm; third, this land usually receives a heavier application of fertilizer and may have more benefit from vegetable matter plowed under than does land worked in other ways. The large variation in yield of crops found in this area was not due so much to the difference in the quality of the soil upon which they are grown as to the difference in method of tillage, holding soil fertility, and planting of seed. Keeping up the productiveness of these soils is a problem of much concern. Practically all these farmers have to depend upon growing crops for supplying organic matter, a thing vital to the maintenance of productiveness in this region. With the long growing season a tremendous quantity of organic matter is used up each year. The soils also lose considerably from erosion unless they are kept well covered. By plowing under cotton and corn stalks and leguminous crops, together with the aid of fertilizer, many of these farmers are keeping their land in a comparatively high state of fertility. Some of these farms could realize substantial increases in yields by selecting better seed as to germination and climatic adaptation, using better tillage methods, and exercising more care in the choice of fertilizers and their application. The yields of crops on the farms in the different tenure classes show some variation, but the comparison of most importance in Table XI is that between the yields received on the farms of white and of colored operators. A bale of cotton, as used in the discussion throughout this bulletin, means 500 pounds of lint cotton. The average yield of cotton on the 317 farms operated by white farmers was 0.55 of a bale per acre, while on the 217 farms operated by colored farmers it was 0.41 bale per acre. Corn on the average yielded 4 bushels per acre higher upon the white-operator farms than upon the colored-operator farms.

TABLE XI.—*Relation of tenure to yields of crops per acre (534 farms, Sumter County, Ga.).*

| Crop. | White operators (317 farms). | | | | | Colored operators (217 farms). | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Owners. | Owners additional. | Owners part rented out.[a] | Tenants. | All white operators. | Owners. | Owners additional. | Owners part rented out.[a] | Tenants. | All colored operators. |
| Yield per acre of— | | | | | | | | | | |
| Wage cotton........bales.. | 0.61 | 0.66 | 0.57 | 0.45 | 0.58 | 0.41 | 0.43 | 0.33 | 0.42 | 0.42 |
| Share cotton.........do.... | .53 | .51 | .53 | .46 | .52 | .37 | .46 | .34 | .41 | .39 |
| Total cotton......do.... | .56 | .57 | .55 | .46 | .55 | .41 | .44 | .34 | .42 | .41 |
| Wage corn.......bushels.. | 16.00 | 16.00 | 10.00 | 12.00 | 14.00 | 8.00 | 9.00 | 9.00 | 9.00 | 9.00 |
| Share corn...........do.... | 13.00 | 11.00 | 12.00 | 13.00 | 13.00 | 8.00 | 11.00 | 8.00 | 9.00 | 8.00 |
| Total corn.........do.... | 15.00 | 14.00 | 11.00 | 12.00 | 13.00 | 8.00 | 10.00 | 8.00 | 9.00 | 9.00 |
| Sweet potatoes......do.... | 103.00 | 117.00 | 104.00 | 77.00 | 102.00 | 62.00 | 107.00 | 62.00 | 79.00 | 75.00 |
| Oats for grain........do.... | 26.00 | 30.00 | 25.00 | 32.00 | 27.00 | 10.00 | 26.00 | 8.00 | 16.00 | 16.00 |
| Cowpea hay..........tons.. | .59 | .42 | .74 | .61 | .61 | .25 | .73 | .54 | .50 | .49 |
| Cane sirup........gallons.. | 181.00 | 161.00 | 191.00 | 202.00 | 182.00 | 209.00 | 96.00 | 153.00 | 138.00 | 122.00 |

[a] Does not include crops on land rented out.

Only small areas per farm are devoted to raising sweet potatoes, yet the differences in yield per acre upon the colored and white farms would be of some importance in supplying family needs.

A very small acreage of oats is raised for grain upon the colored-operator farms, and the yield is 11 bushels less per acre than on the white-operator farms. Cowpeas when grown with good methods produce as high as 2 or 3 tons per acre, but owing to the wide range of methods practiced upon these farms the average yield is very low. the white operators getting but 0.61 ton and the colored operators but 0.49 ton per acre.

Sugar cane yielded an average of 182 gallons of sirup per acre on the white-operator and 122 gallons upon the colored-operator farms. The average area devoted to sugar cane by the colored operators was 0.45 acre. If they had realized yields equaling those of the white operators they would have had 27 more gallons of sirup per family.

The share croppers are getting on the average 0.13 bale of cotton and 5 bushels of corn more per acre on the white-operator farms than they receive on the colored-operator farms. In a comparison of the share-croppers' yields of cotton and corn with those of the colored tenants, it will be observed that the croppers have a considerable advantage. The colored tenants are getting on the average 0.42 bale of cotton and 9 bushels of corn per acre. The share croppers on the white-operator farms are getting 0.52 bale of cotton and 13 bushels of corn per acre. The white tenants also get better yields of crops than the colored tenants. While it is true some of these tenants are on the poorer soil types, yet that is only one factor, as the greater portion of the colored tenants represented in this study are farming on the same farms with the share croppers. Where tenants do not know how to direct the operation of a farm and need supervision, they are better off as share croppers, as then they receive the benefit of the landowner's experience in farming.

There is no doubt that on the soils farmed year after year by many of these colored farmers the supply of vegetable matter is being depleted much faster than where the use of more crops, such as cowpeas, velvet beans, etc., is practiced to supply the soil with nitrogen and keep it in good mechanical condition. Better farm practice is the governing factor in returning the white farmers the higher yields. Many of them plow under heavy leguminous crops to supply vegetable matter to the soil, and they use more fertilizer and practice better tillage methods than does the colored farmer. The latter, as a rule, is very deficient in many of these respects.

## SIZE OF FARM.

Where farms are devoted almost entirely to raising crops, as they are in Sumter County, the size of the farm is the most important factor bearing upon the effective use of capital and labor involved in the operation of the farm. In Tables XII to XXIV the number of tilled acres per farm has been used as the measure of size of farm.

### RELATION OF SIZE OF FARM TO AMOUNT AND DISTRIBUTION OF CAPITAL.

In many regions the amount and distribution of capital necessary in operating a farm depend upon the type of farming one desires to follow. Since only one type prevails in this region, the only influencing factor on amount and distribution of capital is the size of the farm business.

The relation of size of farm to amount and distribution of farm capital on the 160 white-owner farms is shown in Table XII. The farms in the smallest size group average 34 tilled acres and have $3,000 capital; in the next group they average 74 acres and have $6,365 capital; in the third size group they average 123 tilled acres and have $10,226 capital; in the fourth size group they average 194 tilled acres and have $16,190 capital; in the fifth group they average 328 tilled acres and have $30,921 capital, and in the largest size group they average 595 tilled acres and have $53,253 capital. The average amount of capital in these different size groups is practically the same per tilled acre.

When the capital is divided into real estate and working capital, we find the former item comprising approximately 80 per cent of the total capital in each size group, and working capital 20 per cent. It is when these two items are subdivided that differences in the size groups are found.

TABLE XII.—*Relation of size of farm to distribution of capital on 160 farms operated by white owners, Sumter County, Ga.*

| Distribution of capital. | Farms grouped according to the number of tilled acres per farm. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 50 acres and less. | 51 to 100 acres. | 101 to 150 acres. | 151 to 250 acres. | 251 to 450 acres. | Over 450 acres. | Total. |
| Number of farms | 25 | 41 | 40 | 31 | 12 | 11 | 160 |
| Number of tilled acres per farm | 34 | 74 | 123 | 194 | 328 | 595 | 158 |
| Total capital per farm | $3,000 | $6,365 | $10,226 | $16,190 | $30,921 | $53,253 | $13,773 |
| Percentage of total capital in— | | | | | | | |
| Land | 58.5 | 63.1 | 61.3 | 62.7 | 68.5 | 69.7 | 65.1 |
| Houses | 14.5 | 9.1 | 10.4 | 8.4 | 4.3 | 2.5 | 6.8 |
| Tenant houses | 1.6 | 4.1 | 4.3 | 5.3 | 4.6 | 5.9 | 4.8 |
| Gin and equipment | ........ | ........ | .1 | .4 | 2.0 | 2.2 | .9 |
| Other buildings | 5.7 | 4.1 | 4.0 | 3.2 | 2.1 | 2.1 | 3.3 |
| Total real estate | 80.3 | 80.4 | 80.1 | 80.0 | 81.5 | 82.4 | 80.9 |
| Workstock | 7.2 | 7.2 | 7.3 | 7.7 | 8.2 | 6.5 | 7.3 |
| Other live stock | 2.5 | 1.9 | 1.7 | 1.6 | 1.0 | .4 | 1.3 |
| Machinery | 2.8 | 2.8 | 2.6 | 2.8 | 2.7 | 2.9 | 2.8 |
| Feed and supplies | 4.8 | 4.7 | 5.5 | 5.9 | 4.5 | 4.5 | 5.0 |
| Cash | 2.4 | 3.0 | 2.8 | 2.0 | 2.1 | 3.3 | 2.7 |
| Total working capital | 19.7 | 19.6 | 19.9 | 20.0 | 18.5 | 17.6 | 19.1 |

The lowest percentage investment in land is found in the smallest-size group of farms and the highest percentage in the largest-size group. With the exception of the second size group the percentage of investment in land increases as the size of farm increases and the percentage of total real estate remains about constant. This means that the percentage investment in buildings must decrease as the farms increase in size. It is noteworthy that the percentage investment in dwelling houses decreases rapidly as the farms become larger. It is 14.5 per cent on the smallest farms and only 2.5 per cent on the largest farms. The percentage of investment in dwellings on the small farms being so high it would seem that these farms should have better dwellings than the large farms; in reality, they are not so good. The average value of dwelling per farm in the various size-groups, beginning with the smallest-farm group is $435, $580, $1,065, $1,362, $1,313, and $1,314. With a farm investment of $3,000, a $435 house comprises 14.5 per cent of the total investment; while with a farm investment of $53,253 a $1,314 house comprises only 2.5 per cent of the total investment. Each of the three groups above 150 acres has the same grade of house, but on the 151 to 250 acre farms the house comprises 8.4 per cent of the total investment, on the 251 to 450 acre farms 4.3 per cent, and on the largest farms 2.5 per cent. Only one-fifth of the farms of the smallest size group have houses worth over $500 and only one has a $1,000 house, while on the farms of the largest size group only one has a house worth less than $1,000.

Quite naturally there are many more tenant houses on the large farms than on the small farms and even the percentage investment in this item increases as the size of farm increases, with the single exception of the 251 to 450 acre group. Only one out of three of the farms with 50 acres or less of tilled land has a tenant house, while of the farms with 51 to 100 tilled acres 83 per cent have tenant houses. All the farms of over 100 tilled acres have tenant houses, ranging in number from 2 to 26, according to size of farm. The farms from 51 to 100 tilled acres average 2; from 101 to 150 acres, 4; from 151 to 250 acres, 6; from 251 to 450 acres, 9; and over 450 acres, 18 per farm.

On the farms of the smallest-size group no cotton gins were found and but 1 until the farms reached over 150 tilled acres. Ginhouses and equipment constitute over 2 per cent of the total investment in the groups of 251 to 450 acres and of over 450 acres.

The investment in barns, sheds, etc., has been grouped under one heading as "other buildings." This investment is relatively higher on the smaller farms, but the relation is not so marked as it is with the dwellings.

Of the working capital the item of "other live stock" is the only one showing any variation from size of farm. On the farms of the smallest size group this item comprises 2.5 per cent of the total investment and then there is a decrease as size of farm increases, until on the farms of the largest size group less than one-half of 1 per cent of the investment is in live stock other than work stock.

The items of work stock, machinery, feed and supplies and cash for operating expenses show practically the same relative importance for all size groups, the variation for any of these items from the average of all farms not equaling 1 per cent.

The highest percentage of investment in cash to run the farm occurs in the largest size group. A large proportion of the men on the larger farms furnished money for the payment of their yearly expenses, yet the average outlay was so large that a number of these had to borrow additional money. There were others who depended entirely upon borrowing for this purpose.

The variation in the different size groups of the investment in work stock is of no consequence. Where a slight variation does exist it is due primarily to a difference in the value of work stock per head.

Table XIII shows the relation of size of farm to the amount and distribution of investment on the 186 farms operated by colored tenants. The amount of capital invested upon these farms by tenant and landlord ranges from about $2,000 to over $7,000. The size of the farm operated by these tenants has no particular bearing upon the proportion of capital invested in real estate, live stock, machinery, and other working capital, excepting in case of the smallest size group. In this group the investment in real estate is high and in work stock low, due mainly to the fact that each of many of these tenants hires a mule. (See Table XIX, p. 44.) The smallest size group averaged 1.2 head of work stock, the middle group 2.3, and the largest size group 4 per farm. If all the men upon these farms had owned their work mules instead of a part of them renting, the proportion of this investment would have run practically normal in all groups. The investment in other live stock was of very minor importance. Three-fourths of these tenants owned cows, the average value per head being $24. Eight out of every 10 of them kept a few hogs for meat and most of them kept from 10 to 30 chickens.

TABLE XIII.—*Relation of size of farm to distribution of capital on 186 farms operated by colored tenants, Sumter County, Ga.*

| Distribution of capital.[a] | Farms grouped according to the number of tilled acres per farm. | | | |
|---|---|---|---|---|
| | 50 acres and less. | 51 to 100 acres. | Over 100 acres. | Total. |
| Number of farms | 96 | 68 | 22 | 186 |
| Number of tilled acres per farm | 35 | 68 | 136 | 59 |
| Total capital per farm | $2,021 | $3,418 | $7,751 | $3,2 |
| Percentage of total capital in— | | | | |
| Land | 76.9 | 75.8 | 78.5 | 77.0 |
| Tenant houses | 6.8 | 5.3 | 5.1 | 5.7 |
| Other buildings | 2.4 | 2.2 | 1.5 | 2.0 |
| Total real estate | 86.1 | 83.3 | 85.1 | 84.7 |
| Work stock | 6.7 | 8.3 | 7.9 | 7.6 |
| Other live stock | 1.7 | 1.4 | .9 | 1.4 |
| Machinery | 2.0 | 2.2 | 1.6 | 2.0 |
| Feed and supplies | 3.3 | 4.5 | 3.7 | 3.9 |
| Cash | .2 | .3 | .8 | .4 |
| Total working capital | 13.9 | 16.7 | 14.9 | 15.3 |

[a] Landlord's and tenant's capital combined.

The fact that a large percentage of these colored tenants used for the breaking, preparation of the land, covering of the seed, and the cultivation of the intertilled crops, but one crude plow drawn by one mule, explains why the working capital represents less than 15 per cent of the total investment on these farms. The quality of the buildings furnished these tenants is much below that used by the owners. The climate here is such that cheap buildings are very comfortable during the greater part of the year. This, together with self-interest, prompts landlords to build as cheaply as possible.

## RELATION OF SIZE OF FARM TO PROFITS.

The size of the business is one of the most important factors affecting farm profits. A farm must do a certain amount of business in order to yield a satisfactory income. The small farm has relatively much more of its capital in the form of unproductive investment than does the large farm. Labor, mules, and machinery cover relatively smaller areas on the small farm than on a good-sized one and are not so easily kept continuously busy. Moreover, the overhead charges are proportionately smaller on the larger farms.

In Table XIV is shown the relation of size of farm to capital, receipts, expenses, farm income, and labor income on the white-owner farms. The farmer on the farm of the smallest size group, with $3,000 capital, made a farm income of $288 and a labor income of $138. Even if these men were free from debt, so that the payment of interest would not be necessary, they would rarely be able to save any money after paying the year's living expenses out of a farm income of $288.

The men operating farms of from 51 to 100 tilled acres and having twice as much capital as those of the first group are making a labor income of $307, while the men with 101 to 150 tilled acres are making a labor income of $636, which is over double that of the group below them. The capital invested by the men in this group is over three times that of the first-size group.

TABLE XIV.—*Relation of size of farm to capital, receipts, expenses, and income on 160 farms operated by white owners, Sumter County Ga.*

| Tilled acres per farm. | Number of farms. | Average capital. | Receipts. | Expenses. | Farm income. | Labor income. |
|---|---|---|---|---|---|---|
| 50 acres and less | 25 | $3,000 | $794 | $506 | $288 | $138 |
| 51 to 100 acres | 41 | 6,365 | 1,773 | 1,148 | 626 | 307 |
| 101 to 150 acres | 40 | 10,226 | 3,186 | 2,039 | 1,147 | 636 |
| Total, 150 and less tilled acres | 106 | 7,028 | 2,075 | 1,333 | 743 | 391 |
| 151 to 250 acres | 31 | 16,190 | 5,749 | 3,565 | 2,184 | 1,374 |
| 251 to 450 acres | 12 | 30,921 | 8,639 | 5,682 | 2,957 | 1,411 |
| Over 450 acres | 11 | 53,253 | 17,528 | 11,642 | 5,886 | 3,223 |
| Total, over 150 tilled acres | 54 | 27,013 | 8,791 | 5,681 | 3,110 | 1,759 |
| Grand total | 160 | 13,773 | 4,342 | 2,800 | 1,542 | 853 |

Of all the 160 farms operated by white owners, there were 66 per cent with 150 or less tilled acres per farm. The average capital on these farms was $7,028, and they made a labor income of $391. In other words, two-thirds of these owners got on the average less than $400 for their year's labor. The other one-third, with larger farms and an average of $27,013 capital, made an average labor income of $1,759. The volume of business on these farms was over four times that on the farms of less than 150 tilled acres. The farms with the larger business give in proportion larger profits, providing the business is profitable. If, however, a farmer is doing a losing business, the less he does of it the better.

In Table XV is given the relation of the size of farm to capital, receipts, expenses, and profits of the tenant, and the landlord's per cent upon investment on 186 colored-tenant farms. Over one-half of these tenants were on farms of 50 or less tilled acres, and with an average of $281 capital they made an average labor income of $196. The value of family labor was $91, and by adding this amount to the farm income the average family income is $301 for this group. The landlord on these same farms had an average investment of $1,740 and made a profit of 8.8 per cent.

The tenants on farms of from 51 to 100 tilled acres in size, with an investment of $573 apiece, made an average labor income of $357. The value of family labor was $237, family income was $622, landlord's profit 10.3 per cent.

The tenants in the largest size group, with over four times as much capital as those of the smallest-size group, made an average labor income of $573. Family labor was valued at $292, family income was $1,029, and landlord's profit 7.4 per cent.

TABLE XV.—*Relation of size of farm to capital, receipts, expenses, and income of operator and landlord on 186 colored tenant farms, Sumter County, Ga.*

| Tilled acres per farm. | Number of farms. | Average capital. | Receipts. | Expenses. | Farm income. | Family labor. | Labor income. | Landlord's capital. | Landlord's profit (per cent). |
|---|---|---|---|---|---|---|---|---|---|
| 50 acres and less | 96 | $281 | $336 | $326 | $210 | $91 | $196 | $1,740 | 8.8 |
| 51 to 100 acres | 68 | 573 | 1,120 | 735 | 385 | 237 | 357 | 2,845 | 10.3 |
| Over 100 acres | 22 | 1,154 | 2,332 | 1,595 | 737 | 292 | 679 | 6,597 | 7.4 |
| Total | 186 | 491 | 962 | 626 | 336 | 168 | 312 | 2,719 | 8.9 |

Of the 186 colored tenants 182, or practically 98 per cent, were operating farms of 150 or less tilled acres per farm. These men had an average of $459 capital, and made a farm income of $316 and a labor income of $293. The average capital of the landlord was $2,543; profit 9.1 per cent.

The profits of these tenants were in direct proportion to the size of business they were able to handle. The tenant farming the most acres usually had the largest family, and the value of the labor performed by the family was highest. The older tenants were on the larger farms. In the smallest size group their average age was 42, in the next larger size group it was 44, and in the largest size group it averaged 48 years. The tenants reported hauling their cotton an average of 5.8 miles to market, with no relative difference between the size-groups. Tenants with a small amount of capital devoted to crop farming have greater opportunities in this region than in regions where live stock is essential, because the live-stock enterprise calls for much additional investment above that required for raising crops.

## RELATION OF SIZE OF FARM TO DISTRIBUTION OF CROP AREA.

In Table XVI is shown the relation of the number of acres of tilled land per farm to the distribution of crop area on the white-owner farms. The farms in the smallest size group had 45.9 per cent of the crop area devoted to cotton and 38.4 per cent devoted to corn, while those in the largest size group had 64.3 per cent of the crop area in cotton and 22.3 per cent in corn. Every one of the 160 farmers raised both cotton and corn; 21 of these men had below 40 per cent of their crop area in cotton, and 12 had over 70 per cent; 15 had less than 20 per cent of their crop land in corn, and 37 had over 40 per cent.

TABLE XVI.—*Relation of size of farm to distribution of crop area on 160 farms operated by white owners, Sumter County, Ga.*

| Crop. | Percentage of crop area in each specified tilled acreage group. | | | | | |
|---|---|---|---|---|---|---|
| | 50 acres and less. | 51 to 100 acres. | 101 to 150 acres. | 151 to 250 acres. | 251 to 450 acres. | Over 450 acres. |
| Wage cotton | 31.5 | 22.1 | 13.1 | 19.9 | 25.9 | 25.7 |
| Share-cropper cotton | 14.4 | 25.7 | 39.4 | 37.3 | 30.9 | 38.6 |
| Total cotton | 45.9 | 47.8 | 52.5 | 57.2 | 56.8 | 64.3 |
| Wage corn | 34.3 | 22.3 | 14.8 | 13.7 | 16.9 | 9.5 |
| Share-cropper corn | 4.1 | 13.9 | 16.2 | 15.2 | 10.4 | 12.8 |
| Total corn | 38.4 | 36.2 | 31.0 | 28.9 | 27.3 | 22.3 |
| Oats for grain | 6.3 | 8.5 | 9.1 | 9.1 | 11.9 | 9.0 |
| Wheat and rye for grain | .2 | .1 | .7 | .8 | .1 | .2 |
| Cowpea hay and seed | 1.3 | .8 | .8 | (1) | .8 | .3 |
| Second crop | 12.4 | 10.1 | 11.3 | 11.4 | 13.4 | 14.3 |
| Other hay and forage | 1.3 | 2.2 | .8 | .8 | .9 | .7 |
| Second crop | ........ | 1.0 | .4 | 1.3 | 1.3 | ........ |
| Peanuts | 2.8 | 1.7 | 2.5 | 1.2 | .4 | .7 |
| Second crop | 1.6 | 1.4 | 2.5 | 2.1 | .3 | ........ |
| Sorghum | .1 | .2 | .2 | .3 | .2 | .5 |
| Sugar cane | .7 | .5 | .5 | .3 | .2 | .2 |
| Sweet potatoes | 1.1 | .6 | .6 | .3 | .5 | .3 |
| Watermelons | .7 | .4 | .4 | .1 | .4 | .4 |
| Garden, truck, etc | 1.2 | .9 | .6 | 1.0 | .4 | 1.0 |
| Fruit and nuts | ........ | .1 | .3 | (1) | .1 | .1 |
| Total per cent of crop area used for second crop | 14.0 | 12.5 | 14.2 | 14.8 | 15.0 | 14.3 |

(1) Less than one-tenth of 1 per cent.

Oats for grain were grown on three-fourths of these farms, but the acreage generally was small. On one-half of the farms reporting, less than 10 per cent of the crop area was in oats. Only a few grew wheat or rye for grain, and the proportion of area devoted to these is about the same in all size groups.

Cowpeas are of great importance to all these farmers as a second crop. Of all the land devoted to such crops 85 per cent is occupied by cowpeas. There is no wide variation in the different size groups in area devoted to second crops or hay and forage crops. Practically all the minor crops shown in Table XV are, relatively speaking, grown more extensively on the small farms than on the large farms. The larger farms devote more area to cotton. The small farms tend more to diversification than do the large plantations. Unless the man on the small farm raises feed for stock and products for home use he generally suffers a very serious financial setback in case of a poor year.

Table XVII shows the relation of size of farm to distribution of crop area on colored-tenant farms. This table reveals most strikingly the similarity of crop conditions that exist in each size group. Over 90 per cent of the crop area on these farms is devoted to raising cotton and corn, and the only particular variation in the distribution of this area is that on the larger farms a little more area is devoted to cotton and less to corn. As compared with the white owners in Table XVI, these tenants have about 10 per cent more of the crop area in cotton. This table is of most interest in showing how little attention these farmers give to the growing of crops other than cotton and corn. Besides these crops, oats for grain and forage crops grown for hay are the only ones that occupy over 1 per cent of the tilled area for first crops. The area devoted to second crops is mostly used for growing cowpea hay and seed. Excepting in the smallest size group there is no relation between size of farm operated and proportion of the tilled area used for a second crop by these tenants. They utilize less than one-half as much of the crop area for second crops as do the white operators.

TABLE XVII.—*Relation of size of farm to percentage of crop area devoted to each crop on 186 farms operated by colored tenants, Sumter County, Ga.*

| Crop. | Percentage of crop area in each specified tilled acreage group. | | |
|---|---|---|---|
| | 50 acres and less. | 51 to 100 acres. | Over 100 acres. |
| Wage cotton | 64.9 | 60.2 | 47.7 |
| Share cropper cotton | .4 | 4.6 | 19.4 |
| Total cotton | 65.3 | 64.8 | 67.1 |
| Wage corn | 27.9 | 26.2 | 18.2 |
| Share cropper corn | .2 | 1.1 | 6.8 |
| Total corn | 28.1 | 27.3 | 25.0 |
| Oats for grain | 1.9 | 3.0 | 3.0 |
| Wheat and rye for grain | ........ | ........ | (a) |
| Cowpea hay and seed | .1 | .4 | 1.3 |
| Second crop | 6.9 | 4.8 | 5.6 |
| Other hay and forage | 2.3 | 2.0 | 1.5 |
| Second crop | 1.3 | .3 | .5 |
| Peanuts | .2 | .5 | .6 |
| Second crop | .3 | .1 | ........ |
| Sorghum | .2 | .2 | .2 |
| Sugar cane | .3 | .5 | .3 |
| Sweet potatoes | .5 | .5 | .4 |
| Watermelons | .3 | .3 | .2 |
| Garden truck, etc | .8 | .5 | .4 |
| Total cotton and corn | 93.4 | 92.1 | 92.1 |
| Total all other crops | 6.6 | 7.9 | 7.9 |
| Total per cent of crop area used for second crop | 8.5 | 5.2 | 6.1 |

[a] Less than one-tenth of 1 per cent.

## RELATION OF SIZE OF FARM TO DISTRIBUTION OF FARM RECEIPTS.

Table XVIII shows the relation of size of farm to distribution of receipts on the farms operated by white owners. With the exception of the farms of the smallest size and largest size groups, the receipts from cotton and seed have about the same relative weight in all the size groups. The smallest size group has the greatest diversity of receipts, while the largest size group has the least. This substantiates the data shown in Table XVI, which brings out the fact that the men on the small farms devoted less area to cotton and more to the raising of diversified crops.

Of these 160 farmers, only 1 in 7 received less than 70 per cent of his total receipts from the sale of cotton and seed, while over one-fourth the number had over 90 per cent of their receipts from this one source. Cotton ranges from 76 per cent to 91 per cent of the total receipts in the several size groups. Only 9 men received more than 10 per cent of their total receipts from the sale of corn. The receipts from this source range from 1.5 per cent in the smallest size to 3.7 per cent in the largest size group. Nearly all the grain receipts are from the sale of oats. Thirty-two farms reported the sale of oats, but on 28 of these the receipts from this source were less than 10 per cent of the total. Very little hay was sold. Twenty-five farms, a few from each group, reported receipts from hay, but on only 3 of these farms did the receipts exceed 10 per cent of the total sales. Fifty-nine of these men sold cane sirup, but the receipt from this source was usually below 5 per cent of the total and only exceeded 10 per cent on 2 farms. Thirty-three farmers sold a few sweet potatoes and 9 received small receipts from the sale of fruit or nuts. Miscellaneous crop receipts include sales on a few farms and in small amounts of cowpea seed, peanuts, watermelons, and garden products.

TABLE XVIII.—*Relation of size of farm to type of farming, as indicated by sources of income on 160 farms operated by white owners, Sumter County, Ga.*

| Source of income. | Percentage of total receipts in each specified tilled-acreage group. | | | | | |
|---|---|---|---|---|---|---|
| | 50 acres and less (25 farms). | 51 to 100 acres (41 farms). | 101 to 150 acres (40 farms). | 151 to 250 acres (31 farms). | 251 to 450 acres (12 farms). | Over 450 acres (11 farms). |
| Cotton | 69.1 | 74.8 | 75.2 | 75.0 | 72.9 | 78.4 |
| Cotton seed | 7.1 | 9.6 | 10.5 | 10.1 | 12.2 | 12.5 |
| Total cotton | 76.2 | 84.4 | 85.7 | 85.1 | 85.1 | 90.9 |
| Corn | 1.5 | 2.5 | 3.8 | 3.7 | 3.1 | 3.7 |
| Small grains | .5 | .8 | .8 | 1.0 | 2.0 | 1.5 |
| Hay | .9 | .5 | .3 | 1.0 | .6 | 1.0 |
| Cane sirup | 1.4 | .8 | .6 | 1.1 | .5 | .1 |
| Sweet potatoes | .5 | .3 | .5 | (a) | .6 | .2 |
| Fruit and nuts | .1 | (a) | .2 | (a) | ........ | ........ |
| Miscellaneous crops | .7 | .5 | .6 | .2 | .7 | .5 |
| Total crops | 81.8 | 89.8 | 92.5 | 92.1 | 92.6 | 97.9 |
| Increase feed and supplies | 6.3 | 1.6 | .5 | 1.3 | ........ | .3 |
| Cattle | 3.4 | 1.8 | 2.0 | .4 | .3 | (a) |
| Horses and mules | .8 | ........ | .3 | .1 | .6 | ........ |
| Hogs | 3.4 | 2.3 | 2.4 | 4.7 | 1.4 | .3 |
| Poultry | 2.2 | 1.2 | 1.2 | .2 | .4 | (a) |
| Bees [b] | .1 | (a) | ........ | ........ | ........ | ........ |
| Total stock | 9.9 | 5.3 | 5.9 | 5.4 | 2.7 | .3 |
| Miscellaneous sources | 2.0 | 3.3 | 1.1 | 1.2 | 4.7 | 1.5 |

[a] Less than one-tenth of 1 per cent.

[b] Two farms reported small sales from bees.

The receipts for practically all the farm crops sold, outside of cotton and seed, are of a local nature, as very few of these crops are shipped out of the county.

The increase in feed and supplies represents a gain in the amount and value of feeds and other farm supplies at the end of the year over that on hand at the beginning of the year. This item was of no consequence, excepting in the smallest-size group, where an increased amount of cotton seed was held over for seed, feed, and fertilizing purposes. The receipts from crops and feed and supplies constituted over 98 per cent of the total receipts upon the farms in the largest-size group.

The receipts from the sale of cattle, hogs, and poultry and their products were relatively of more importance to the farmers with the smaller farms. Live stock and products constituted 9.9 per cent of the total receipts on the farms in the smallest-size group and less than 1 per cent in the largest-size group. As a general rule, above the mules necessary for carrying on the farm work, only enough live stock is kept to use up the feed crops raised on the farm that have no sale value.

The receipts from miscellaneous sources are of minor importance and vary from 1.1 to 4.7 per cent.

Table XIX shows the relation of size of farm to the distribution of receipts on colored-tenant farms. Over 90 per cent of the total farm sales from these farms comes from cotton alone. On the average, no other farm receipt equals 1 per cent of the total, excepting feed and supplies and outside labor. No variation is shown between the size of farm and distribution of receipts.

**TABLE XIX.**—*Relation of size of farm to distribution of farm receipts on 186 farms operated by colored tenants, Sumter County, Ga.*

| Source of income.[a] | Percentage of total receipts in each specified tilled-acreage group. | | | |
|---|---|---|---|---|
| | 50 acres and less (96 farms). | 51 to 100 acres (68 farms). | Over 100 acres (22 farms). | Total (186 farms). |
| Cotton | 82.2 | 83.0 | 83.4 | 82.8 |
| Cotton seed | 11.7 | 11.0 | 11.4 | 11.4 |
| Total cotton | 93.9 | 94.0 | 94.8 | 94.2 |
| Corn | .2 | .2 | 1.3 | .6 |
| Small grains | | | | |
| Hay | ([b]) | .1 | .1 | ([b]) |
| Cane sirup | .2 | .3 | .2 | .2 |
| Sweet potatoes | .2 | .4 | .1 | .3 |
| Fruit and nuts | | .1 | | ([b]) |
| Miscellaneous crops | .3 | .4 | ([b]) | .2 |
| Total crops | 94.8 | 95.5 | 96.5 | 95.5 |
| Increase in feed and supplies | 2.3 | 2.4 | 2.2 | 2.4 |
| Cattle | .6 | .4 | .5 | .5 |
| Horses and mules | | | | |
| Hogs | | | .1 | ([b]) |
| Poultry | .4 | .3 | .2 | .3 |
| Total stock | 1.0 | .7 | .8 | .8 |
| Outside labor | 1.9 | 1.4 | .5 | 1.3 |

[a] Landlord's and tenant's receipts combined.

[b] Less than one-tenth of 1 per cent.

### RELATION OF SIZE OF FARM TO DISTRIBUTION OF EXPENSES.

Table XX shows the relation of size of farm to the distribution of expenses on the farms operated by white owners. The larger the size of business, the greater becomes the expense for different things, even though the proportion may be constant. The average expense for labor outside that performed by the operator was $196 per farm in the smallest-size group and $5,412 in the largest-size group. About one-half of the labor expense on the largest farms was for share croppers. In all the size-groups, except the first, the expense for labor was over 50 per cent of the total farm expenditures. This low labor cost, so noticeable in the smallest-size group, and also showing to some extent in the 51 to 100 acre group, is due to these farms being of such size that the operator did all or a part of the work of a laborer. After these farms become of such size (about 100 tilled acres) that the operator's time is mostly taken up in the general supervision of the business, the expense for labor is higher and quite uniform. The small farms furnish a greater amount of family labor than the large farms, but this difference is offset by the fact that the larger farms hire more wage hands.

The machinery-repair charge is considerably higher on the larger farms, chiefly because these farms maintain more numerous and more expensive implements than do the smaller farms. The building-repair expense runs quite uniform in all the groups, but repairs of fences are relatively higher upon the smaller farms.

TABLE XX.—*The relation of size of farm to distribution of farm expenses on 160 farms operated by white owners, Sumter County, Ga.*

| Item of expense. | Percentage of farm expenses in each specified tilled acreage group. | | | | | |
|---|---|---|---|---|---|---|
| | 50 acres and less (25 farms). | 51 to 100 acres (41 farms). | 101 to 150 acres (40 farms). | 151 to 250 acres (31 farms). | 251 to 450 acres (12 farms). | Over 450 acres (11 farms). |
| Wage hands | 6.4 | 8.6 | 7.9 | 12.2 | 15.9 | 15.4 |
| Cotton picking and chopping (extra labor). | 2.6 | 6.5 | 4.2 | 5.7 | 8.0 | 9.7 |
| Share croppers | 21.4 | 31.8 | 42.7 | 37.8 | 29.7 | 30.5 |
| Family labor | 15.2 | 4.7 | 3.0 | 1.9 | .5 | ......... |
| Total labor | 45.6 | 51.6 | 57.8 | 57.6 | 54.1 | 55.6 |
| Repairs: | | | | | | |
| Machinery | .5 | .9 | .6 | 1.0 | 1.3 | 2.7 |
| Buildings | 2.6 | 3.6 | 1.8 | 2.0 | 3.0 | 2.2 |
| Fences | 4.3 | .9 | .4 | .6 | .4 | ......... |
| Terracing | .7 | .3 | .3 | .4 | (a) | .2 |
| Feed: | | | | | | |
| Hay, etc | .9 | .6 | .4 | .7 | .6 | .2 |
| Grain, etc | 6.4 | 2.1 | 2.9 | 1.7 | 1.3 | 1.1 |
| Horseshoeing | .3 | .4 | .2 | .2 | .3 | .1 |
| Breeding fees and veterinary | (a) | .2 | .2 | .2 | .2 | .1 |
| Seeds and plants | 2.2 | 1.1 | .8 | 1.1 | .4 | .8 |
| Fertilizer: | | | | | | |
| Croppers | 5.7 | 10.3 | 15.9 | 12.6 | 11.2 | 14.8 |
| Wage land | 20.3 | 17.1 | 9.0 | 12.4 | 17.6 | 14.5 |
| Thrashing and twine | .1 | .2 | .4 | .4 | .3 | .2 |
| Ginning, bags, ties, etc | 4.7 | 5.1 | 5.0 | 4.6 | 5.1 | 3.9 |
| Machine hire, fuel, and oil | .1 | .1 | .2 | .1 | .2 | .6 |
| Insurance | .5 | .3 | .3 | .5 | .5 | .1 |
| Taxes | 3.5 | 3.1 | 2.5 | 2.5 | 2.4 | 1.6 |
| Interest on loan | .8 | 1.2 | 1.0 | 1.1 | .4 | .6 |
| Miscellaneous | .8 | .9 | .3 | .3 | .7 | .7 |

[a] Less than one-tenth of 1 per cent.

The purchase of feed is a small item of expense when considering all these farms together, but in this study of the farms in the several size-groups most of the feed that is purchased is bought by the smaller farms and consists chiefly of grain and concentrate feeds.

The cost of fertilizer was $112 per farm for the smallest-size group and $3,032 for the largest-size group. The larger farms have the higher percentages of expenses for fertilizer. This is in accord with Table XVI, which shows that these large farms raise more cotton. Practically all the small farmers hire their cotton ginning done. while many of the farmers on the large farms own gins. The outlay per bale, however, is about the same in either case. when the expense for cloth, ties, interest, depreciation, etc., are all considered.

Taxes are proportionately higher upon the small farms. ranging from 3.5 per cent for the smallest-size group to 1.6 per cent for the largest-size group. The interest charge on the loan for carrying on the farm business during the year is of only minor importance when compared with cash expenses as a whole.

TABLE XXI.—*Relation of size of farm to distribution of farm expenses on 186 farms operated by colored tenants, Sumter County, Ga.*

| Item of expense.[a] | Percentage of farm expenses in each specified tilled acreage group. | | |
|---|---|---|---|
| | 50 acres and less (96 farms). | 51 to 100 acres (68 farms). | Over 100 acres (22 farms). |
| Wage hands | 2.1 | 4.3 | 6.3 |
| Cotton picking and chopping (extra labor) | 4.5 | 3.7 | 6.8 |
| Share croppers | .6 | 4.0 | 20.6 |
| Family labor | 30.2 | 34.4 | 19.3 |
| Total labor | 37.4 | 46.4 | 53.0 |
| Repairs: | | | |
| Machinery | .6 | .9 | .6 |
| Buildings | .3 | 1.3 | .3 |
| Fences | .7 | .4 | .4 |
| Terracing | .5 | .2 | ........ |
| Feed: | | | |
| Hay, etc | 2.2 | 1.7 | 1.4 |
| Grain, etc | 6.4 | 4.3 | 3.5 |
| Horseshoeing | .2 | .2 | .2 |
| Breeding fees and veterinary | .2 | .1 | (b) |
| Seeds and plants | 1.4 | 1.0 | .9 |
| Fertilizer: | | | |
| Croppers | .2 | 1.7 | 8.8 |
| Wage land | 32.9 | 27.8 | 18.0 |
| Thrashing and twine | ........ | (b) | (b) |
| Ginning, bags and ties | 7.6 | 7.4 | 6.7 |
| Machine hire, fuel and oil | (b) | .1 | .1 |
| Insurance | .1 | (b) | .2 |
| Taxes | 4.5 | 3.4 | 3.2 |
| Interest on loan | 3.5 | 2.4 | 2.4 |
| Miscellaneous | (b) | (b) | .1 |
| Mule hire | 1.3 | .7 | .2 |

[a] Landlord's and tenant's expenses combined. [b] Less than one-tenth of 1 per cent.

In Table XXI is shown the relation of size of farm to distribution of expenses on 186 colored-tenant farms. It will be observed that, with the exception of a little labor in "chopping" and picking cotton, all the labor on the farms of 50 or less tilled acres is performed by the operator and his family. Even on the farms between 50 and 100 tilled acres the operator and his family did the greater portion of the work. On the farms above 100 tilled acres in size the labor expense was 53 per cent of the total expenses. Most of the additional labor necessary in operating the large farms is performed by share croppers. These men buy considerable feed, purchases averaging 2 per cent for roughage and 5 per cent for grain feeds. Practically all this purchased feed is for the keep of work mules, as the mule represents about all the stock of the farm of this type, aside from a cow and a few chickens. This item seems to be most important upon the very small farms.

The expense for fertilizer is 30 per cent of the total. This expense averaged $100 per farm in the smallest-size group and $406 in the largest-size group. Many of the tenants have little or no capital free from mortgage, and in order to purchase fertilizer on credit they are compelled to pay exorbitant prices to cover the greater risk. The expense for taxes averaged 4.5 per cent upon the smallest-size group and 2.9 per cent on the largest-size group. Practically all the tenants borrow money for the payment of operating expenses and pay rather high interest rates. This item ranges from 3.5 per cent of the total cash expenses in the smallest-size group to 2.2 per cent on the largest-size group. Labor and fertilizer constitute three-fourths of the total expenses of the 186 farms.

### RELATION OF SIZE OF FARM TO YIELD OF CROPS.

In Table XXII is shown the relation between size of farm and yield of crops on the 160 white-owner farms.

In a region devoted strictly to crop farming, and especially where the area devoted to one intensive crop, as cotton, occupies over one-half of the available crop land, the yield and price received for this crop becomes of first importance in relation to profits. The yield of cotton is so closely associated to farm profits that the large farmer as well as the small farmer is striving for maximum yields. It will, therefore, be noticed from Table XXII that size of farm does not materially influence the yield of cotton.

The yield of corn varies in the several size groups, with a tendency to somewhat higher yields upon the large farms. The three smaller size groups are each below the average, 15 bushels, while the three larger-size groups are each above that average.

In a comparison of the yield of oats for grain, the large farms seem to have a slight advantage.

TABLE XXII.—*Relation of size of farm to yield per acre of crops on 160 farms operated by white owners, Sumter County, Ga.*

| Crop. | Yield of crops per acre in each specified tilled acreage group. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 50 acres and less | 51 to 100 acres. | 101 to 150 acres. | 151 to 250 acres. | 251 to 450 acres. | Over 450 acres. | Total. |
| Wage cotton......................bale.. | 0.50 | 0.58 | 0.62 | 0.68 | 0.55 | 0.63 | 0.61 |
| Share-cropper cotton.............do.... | .52 | .57 | .54 | .56 | .50 | .50 | .53 |
| Total cotton..............do.... | .51 | .57 | .56 | .60 | .52 | .55 | .56 |
| Wage corn....................bushels.. | 13 | 13 | 14 | 19 | 18 | 19 | 16 |
| Share-cropper corn...............do.... | 14 | 11 | 11 | 14 | 16 | 14 | 13 |
| Total corn................do.... | 13 | 12 | 13 | 17 | 17 | 16 | 15 |
| Oats for grain...................do.... | 28 | 24 | 22 | 24 | 31 | 29 | 26 |
| Cowpea hay......................ton.. | .89 | .66 | .83 | .88 | .67 | .63 | .73 |
| Sweet potatoes................bushels.. | 112 | 112 | 98 | 93 | 100 | 117 | 108 |
| Cane sirup....................gallons.. | 176 | 161 | 154 | 261 | 166 | 135 | 181 |

There is such a wide range of method in managing the cowpea crop that it is hard to make a comparison of the yields on farms of different size. In this area cowpeas are most commonly grown after winter oats or other grains and used for hay, while the crop for seed is usually grown between the corn rows. Table XXII shows that on the average these men harvested about three-fourths of a ton per acre of this crop and that the size of the farm had no appreciable bearing upon the yields received.

Sweet potatoes were raised for home use on a majority of the farms, but the yield was not affected in any way by the size of the farm. The yield ranged from 93 to 117 bushels per acre.

The growing of sugar cane was mostly for home use. This crop averaged one-half acre per farm, yielding at the rate of 181 gallons of cane sirup per acre, and showed a wide range in yield for the different groups.

The larger farms devoted relatively more land to cotton and necessarily used more fertilizer per tilled acre, which undoubtedly is the big factor in returning them the larger yields they received from some of the important crops other than cotton.

In Table XXIII is shown the relation between size of farm and yield per acre of crops on the 186 colored-tenant farms.

Cotton, with very little variation in the several size groups, yielded an average of 0.42 bale per acre. On the average, these men had 38 acres of cotton. If they had gotten the same yield as the white owners, they would have had 5 more bales of cotton per farm.

TABLE XXIII.—*Relation of size of farm to yield per acre of crops on 186 farms operated by colored tenants, Sumter County, Ga.*

| Crop. | Yield per acre of crops in each specified tilled acreage group. | | | |
|---|---|---|---|---|
| | 50 acres and less. | 51 to 100 acres. | Over 100 acres. | Total. |
| Wage cotton........bales.. | 0.40 | 0.43 | 0.44 | 0.42 |
| Share-cropper cotton........do.... | .43 | .43 | .41 | .41 |
| Total cotton........do.... | .41 | .43 | .43 | .42 |
| Wage corn........bushels.. | 8 | 9 | 8 | 9 |
| Share-cropper corn........do.... | 6 | 9 | 9 | 9 |
| Total corn........do.... | 8 | 9 | 9 | 9 |
| Oats for grain........do.... | 10 | 17 | 16 | 16 |
| Cowpea hay........tons.. | .59 | .66 | .40 | .52 |
| Sweet potatoes........bushels.. | 68 | 94 | 59 | 79 |
| Cane sirup........gallons.. | 116 | 131 | 175 | 138 |

There was an average of 16 acres of corn per farm, with a yield of only 9 bushels per acre. If their average yield had been as high as that of the owners shown in Table XXII these men would have averaged nearly 100 more bushels of corn for farm and home use. This would have reduced their feed bill, shown in Table XXI, considerably. Cotton and corn, as shown in previous tables, occupied over 90 per cent of the crop area worked by these tenants, and many of them had practically all their tilled area in these two crops.

A total of 50 acres of sweet potatoes, or a little over one-fourth acre per farm, were raised by the tenants, with an average yield of 79 bushels per acre.

An average of less than one-fourth acre of sugar cane was grown, with a yield of 138 gallons of cane sirup per acre.

Oats for grain were not grown so generally by the colored as by the white farmers. The oats that were cut for grain averaged less than 1 acre per farm, with a yield of about 16 bushels per acre. Eighty per cent of the oats raised by these farmers was cut for hay, with an average yield of 0.66 ton per acre. There was an average of about 2 acres of cowpeas for hay grown on these farms, which yielded 0.52 ton per acre.

The size of the farm operated by these tenants has very little bearing on method of operation or yields received. By only a slight change in the management of these farms they could be made to return adequate forage and grain crops for farm and home use. While about 10 per cent of these men operate farms with poorer soil, the unproductive, impoverished condition of much of the land they farm is due largely to the continuous growing of poor crops of cotton on the same soil year after year by the use of commercial fertilizer and without the addition of anything to the soil in the way of vegetable matter. It is also quite probable that by using better machinery and practicing better tillage methods the yields could be raised considerably.

### RELATION OF SIZE OF FARM TO TYPE OF MACHINERY USED.

*Twenty-five farms with 50 tilled acres or less.*—On these farms there were usually found a one or two horse wagon, 1 to 4 one-horse plow stocks, a cotton planter, plow and wagon gears for the work stock, and necessary hand tools. In addition to these items, two-thirds of these farms had one or two horse turning plows, one-half had one-horse fertilizer distributors, and 3 farms each had a mower and hay rake. It was only an occasional farm that had any cultivating tools other than plow stocks.

*Forty-one farms with 51 to 100 tilled acres.*—One-half of these farms had more than 1 wagon, usually a one-horse and a two-horse wagon. Practically all had a two-horse turning plow, and an occasional farm had 2. In addition to the two-horse plows, about one-third of these farms had one-horse plows. Of the cultivating tools every farm had one-horse plow stocks, and 3 farms had two-horse stocks. In addition to plow stocks, one-third of them reported other types of one-horse cultivating tools, and 1 farm had a two-horse cultivator. One-half of these farms had two-horse harrows, usually a disk, but occasionally a spike-tooth. One-half had each a mower and hay rake, and 5 reported grain binders.

*Seventy-one farms with 101 to 250 tilled acres.*—The one-horse plow stock is found on every farm in this group, but other one-horse cultivating tools are of more frequency than in the groups already discussed, and 1 in 10 had a two-horse cultivator. Mowers, hay rakes, and harrows were found on two-thirds of the farms. One out of every 2 farms reported grain binders. Some items of machinery not found on the smaller farms occur with more or less frequency on farms of this size. Twelve farms had engines, 7 had hay presses, 3 had wood saws, 2 had feed grinders, 2 had pea hullers, 1 had a manure spreader, and 1 a lime spreader.

*Twenty-three farms with 251 tilled acres and over.*—The difference in type of machinery found on these farms from that on the farms of 100 acres and less is quite marked. While the single-plow stock is in general use on farms of all sizes, there is an increase in the use of other one-horse cultivating tools and in the use of two-horse cultivators on the large farms. Seventy per cent of these large farms reported numerous one-horse cultivating tools other than plow stocks and over one-fifth of them had two-horse cultivators. Practically all the farms had harrows, mowers, rakes, and grain binders. One in 3 farms had sulky plows and 3 had tractor plows. Three-fourths of them had engines and several had stump pullers.

### RELATION OF SIZE OF FARM TO THE EFFICIENT USE OF LABOR, MULES, AND MACHINERY.

In Table XXIV is shown the effect size of farm has upon the efficient use of labor, mules, and machinery in this area. The percentage increase of the cotton area is of importance in its relation to the value of labor per tilled acre on the different size farms. The very small farms had but 46 per cent of the tilled area in cotton, while the very large farms had 64 per cent. With but one exception each size-group had a greater percentage of its tilled area devoted to cotton than the next smaller-size group. The value of labor, averaging $11.79 per acre, is rather uniform in all the size-groups, but when we consider that cotton requires a greater amount of labor per acre than most other crops raised in this section, the superior efficiency of the large farms over the small farms in the use of labor is seen. With practically the same amount of labor per tilled acre, the very large farms have 18 per cent more of their area in cotton.

TABLE XXIV.—*Relation of size of farm to various factors of efficiency on 160 farms operated by white owners, Sumter County, Ga.*

| Factor of efficiency. | Tilled acreage groups. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 50 acres and less (25 farms). | 51 to 100 acres (41 farms). | 101 to 150 acres (40 farms). | 151 to 250 acres (31 farms). | 251 to 450 acres (12 farms). | Over 450 acres. | Total (100 farms). |
| Per cent of tilled area in cotton | 46 | 48 | 52 | 57 | 57 | 64 | 57 |
| Value of labor per tilled acre | $11.23 | $11.32 | $12.00 | $12.69 | $10.97 | $11.58 | $11.79 |
| Number of acres of cotton per mule | 10 | 12 | 14 | 16 | 16 | 19 | 16 |
| Number of acres of other crops per mule | 11 | 12 | 12 | 11 | 11 | 10 | 11 |
| Value of machinery per tilled acre | $2.40 | $2.40 | $2.18 | $2.33 | $2.59 | $2.61 | $2.43 |

Another example of increase in efficiency as the farms increase in size is furnished by the work stock. On the smallest farms 1 mule works 10 acres of cotton and 11 acres of other crops. As the farms increase in size the number of acres of cotton per mule increases and the number of acres of other crops remains about constant until on the very large farms 1 mule works 19 acres of cotton and 10 acres of other crops. Thus a mule on any size farm works practically the same number of acres of feed and home-supply crops, but on the very large farms works almost twice as many acres of cotton as the mule on the very small farms.

The value of machinery per tilled acre shows but little variation. There is some difference in the type of machinery found on different size farms, but the large farms are enabled to use a considerable amount of improved and labor-saving machinery with no greater investment per tilled acre than that found on the small farms.

## DIVERSITY OF FARM RECEIPTS.

The tables previously discussed with reference to tenure and size of farm have shown that cotton raising is the major enterprise of this district and that receipts from this crop represent nearly 90 per cent of the income on all the farms. In a study of the 160 farms operated by owners only 12 had less than 60 per cent of their total receipts from the sale of cotton, while three-fourths had over 80 per cent of their income from this one source.

Of the 12 farmers with under 60 per cent of total receipts from cotton, 6 raised diversified crops with cotton as the leading cash crop and hogs as the leading live-stock enterprise. These men bought very little feed. The farms had an average of 121 tilled acres and returned an average labor income of $239. Two farmers got nearly 40 per cent of their total receipts from the sale of dairy cattle and their products. They raised only small areas of cotton and instead devoted most of their crop lands to raising corn, grain, and hay crops. One had 118 acres of crops, 9 cows, 1 bull, 4 horses, 4 brood sows, and 375 chickens. Besides supplying roughage for his live stock, his receipts from crops and other farm sales were as follows: Cotton, $200; corn, $25; sweet potatoes, $50; watermelons, $150; fruit and nuts, $60. From the 9 cows he sold butter at 35 cents per pound to a retail trade, averaging $95 per head, besides receiving a good return from the sale of buttermilk. With 4 sows the receipts from hogs were $233; 375 hens returned $617 from the sale of young chickens and eggs. He operated this farm with the help of two wage hands, hired for 6 months, and made a labor income of over $1,000. The other farm was much smaller, only having 42 acres of well-diversified crops and with 48 per cent of the receipts from cows, hogs, and poultry. This farmer operated with one wage hand 6 months in the year and got nearly $500 for his year's labor.

The only other farmer found following a type of farming different from that of the so-called "cotton farmer" was one operating a large business with a great diversity of income. This farm contained 268 acres of crops, of which 20 per cent was devoted to cotton, 31 per cent to corn, 25 per cent to grain, 23 per cent to cowpea hay, and 3 acres to sugar cane. Ground peas were grown in the corn. The crop yields on this farm as compared with all the farms studied were excellent. The farm sales were as follows: Cotton, $3,743; corn, $1,060; grain, $1,040; hay, $874; cane sirup, $810; pork, $925; other stock, $64. Of this man's grain sales, $1,000 was from the sale of 1,000 bushels of oats for seed. Aside from some corn, his hogs were practically raised and fattened upon ground peas. This farm was operated with the help of three wage hands and one cropper family, and $600 extra labor. It returned the operator a labor income of $4,468. This was the only well-diversified farm found in this study. The returns this man received were dependent upon the demands from local markets. A return of $1 per bushel for corn, $1 per bushel for oats, and $23 per ton for hay is much more than these crops could command if many more were to grow them for the same market.

A farm representative of the cotton type was found which is quite comparable, as to size and soil type, with the diversified farm just mentioned. This farm contained 243 acres of crops, of which 62 per cent was in cotton, 25 per cent in corn, 6 per cent in oats, 5 per cent in cowpea hay, and 2 per cent in other crops. Yields were relatively high. The farm sales were as follows: Cotton and seed, $8,700; corn, $250; oats, $22; sirup, $50; pork, $225; wood, $400. It was operated with the help of six wage hands and two croppers' families and $800 extra labor. It returned the operator a labor income of $4,344. This farm represents a typical cotton farm of this region operated under excellent management. Under its high state of efficiency the cost of producing cotton was below 7 cents per pound. Cotton could be sold from this farm with its present yields at 10 cents per pound and still return the operator over $2,000 labor income.

The fact that only one farmer in the entire area is practicing strictly diversified farming is an indication that care should be exercised in contemplating changes to this type. The cotton type of farming has been practiced for many years in this region and has doubtless become a much easier type of farming for most of these farmers to follow than would a type involving a greater degree of diversity. They have become skilled in the economic use of capital and labor for the production of this crop and at the same time maintaining soil fertility. The small amount of capital owned by many of these farmers will go further when invested in one enterprise than when distributed among many. This type has advantage also in that it permits the use of very large fields, which greatly facilitates the use of the great amount of labor involved in the operation of farms of this type.

On the other hand, diversified farming gives better insurance against total failure and will lend to the eradication of the crisis of the boll weevil which is now invading the county. When properly organized it gives opportunity to use land, labor, mules, and machinery effectively throughout the year. The income is usually more evenly distributed than that from cotton, thus making it easier for the farmer to operate on a cash basis during the spring and summer months, when money is needed for paying farm expenses. Failures are often due to conditions over which the farmer has no control, such as climate, markets, or pests. If a farmer is raising several important crops they are not all liable to fail in any one year.

This also lends itself to the establishment of a crop rotation. A well-planned rotation designed for the improvement of the soil and the increased production of the crops should be the aim of all these farmers. This not only supplies ample farm feeds, but, more important still, aids materially in increasing the production of the main money crop. For, after all, cotton is the staple crop of the region and the general scheme of farming must always be shaped with the welfare of the cotton crop in view.

## THE RELATION OF SIZE OF FARM AND YIELD PER ACRE OF COTTON TO PROFITS.

The two factors which more than all others influence profits on these farms, providing a normal price is received for cotton, are size of farm and yield of cotton per acre. While farmers are not always in a position to increase the size of their farms, Table XXV shows the possibilities many of them have of increasing their profits quite materially by getting higher yields per acre. Along with these two factors, however, are interrelated many others of importance, but when the farms are grouped on the basis of these two outstanding factors the others seem to bring about in each group the same relative results. The yield per acre of cotton is of great importance to all these farmers, but the chance for the greatest immediate increase in profits is for the men who are getting poor yields on the large areas.

TABLE XXV.—*Relation of size of farm and yield of cotton per acre to labor income on 268 white owner, owner additional, and owner part rented out farms, Sumter County, Ga.*

| Tilled acreage groups. | Number of farms and average labor income in each specified yield of cotton per acre groups. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | One-half bale and less. | | One-half to two-thirds bale. | | Over two-thirds bale. | | Total. | |
| | Number of farms. | Average labor income. | Number of farms. | Average labor income. | Number of farms. | Average labor income. | Number of farms. | Average labor income. |
| 100 acres and less | 43 | 120 | 33 | 308 | 24 | 504 | 100 | 275 |
| 101 to 250 acres | [a] 32 | 423 | 46 | 749 | 25 | 1,721 | 103 | 884 |
| Over 250 acres | 30 | 430 | 22 | 3,159 | 13 | 4,649 | 65 | 2,197 |
| All farms | 105 | 301 | 101 | 1,130 | 62 | 1,864 | 268 | 975 |

[a] One of these farms is a dairy farm with high-quality cows.

In regard to the farmers with 100 or less tilled acres per farm it will be observed that these men with cotton yields of one-half bale or less per acre made an average labor income of only $120, while with the same size farms the men with cotton yielding over two-thirds of a bale per acre made an average labor income of $504.

Out of the 103 farm operators with 101 to 250 tilled acres per farm, there were one-third with yields of cotton of one-half bale or less per acre and their average labor income was $423. With farms of the same size the men with cotton yielding over two-thirds of a bale per acre made labor incomes averaging $1,721.

This same trend holds good for the farmers with over 250 tilled acres per farm. The farms of the group producing the lowest yields of cotton returned their operators an average labor income of but $430. Where the cotton yields were over two-thirds of a bale per acre, these large farms brought their operators an average labor income of over $4,000. The possibility for a larger volume of business on these larger farms gives greater opportunity to increase profits by increasing yields than does the limited business of the small farm.

Table XXV is strikingly interesting in that it brings out the fact that even though the larger farms do make much higher incomes on the average, many of them yield little or no income. Size of business is undoubtedly a big factor in successful farming, but it is just as big a factor in failure. The large business conducted without attention to yield of crops and management of labor may result in loss proportionate to the size of the business.

In Table XXVI the relation of size of farm and yield of cotton per acre to labor income is shown for the colored tenants.

**Table** XXVI.—*Relation of size of farm and yield of cotton per acre to labor income on 186 farms operated by colored tenants, Sumter County, Ga.*

| Tilled acres per farm. | Number of farms and average labor income in each specified yield of cotton per acre group. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | One-third bale and less. | | One-third to one-half bale. | | Over one-half bale. | | Total. | |
| | Number of farms. | Average labor income. | Number of farms. | Average labor income. | Number of farms. | Average labor income. | Number of farms. | Average labor income. |
| 50 acres and less...... | 34 | 100 | 44 | 191 | 18 | 389 | 96 | 196 |
| Over 50 acres......... | 20 | 124 | 48 | 462 | 22 | 662 | 90 | 435 |
| All farms...... | 54 | 109 | 92 | 332 | 40 | 539 | 186 | 312 |

The farms are arranged into two size groups, that of 50 or less tilled acres and that of over 50 tilled acres. Each of these two groups is further divided into three groups, those with cotton yielding one-third bale or less per acre, those with one-third to one-half bale per acre, and those with over one-half bale per acre.

In the case of the tenants with 50 or less tilled acres per farm, one-third had cotton yielding one-third bale or less per acre, and made an average labor income of only $100. The tenants in this same size group with cotton yielding over one-half bale per acre made labor incomes of $389 each.

Out of the 90 tenants with over 50 tilled acres per farm, 20 with cotton yielding one-third bale or less per acre, made a labor income of only $124, while those whose cotton yields were over one-half bale per acre had an average labor income of $662.

Only about one-fifth of these tenants raised cotton yielding over one-half bale per acre. The average labor income of these men was $539. One out of every four had yields of one-third bale or less per acre, and these made an average labor income of only $109.

## THE COST OF PRODUCING COTTON.

In an agricultural area devoted almost exclusively to a single enterprise the cost of production per unit for that enterprise may be determined with reasonable accuracy from the data collected through the regular farm-management survey. Such an enterprise is found in Sumter County, where cotton occupies 59 per cent of the crop area and constitutes 89 per cent of the farm receipts. Tables follow illustrating the method used and showing the cost per acre and per pound of lint cotton by tenure and by size of farm and yield per acre.

### METHOD USED IN DETERMINING COSTS.

The method used in determining the cost of producing cotton includes five distinct steps. (1) Finding the percentage of total farm receipts represented by the sale of cotton, including both lint and seed. (2) Finding the total farm operating expense. This is the sum of the general expenses (including such items as labor, repairs, feed, seed, fertilizer, insurance, taxes, etc.), the value of the farmer's own labor, and interest on the capital invested. (3) Calculating the amount of total farm-operating expense chargeable to cotton in proportion to the per cent of total receipts derived from cotton. (4) Finding the net cotton expense by deducting the amount received from the sale of cotton seed from the amount of farm-operating expense chargeable to cotton. (5) Finding the cost per acre or per pound of lint cotton, by dividing the net cotton expense respectively by the number of acres in cotton or by the number of pounds of lint cotton raised.

While this method would not be advisable where there are several leading enterprises, yet it has advantages in regions of this nature. Here the crop area that was not occupied by cotton is utilized almost entirely in growing crops to support the mules and labor used in growing cotton.

In Table XXVII are shown in detail the steps taken in arriving at the cost of production on the 160 farms operated by white owners. On these farms the total receipts were $655,526, of which $569,651, or 86.9 per cent, were from the sale of lint cotton and seed. The total general expenses were $408,876, and by adding to this sum the vaule of the farmers' own labor, $70,451, plus $110,184, which is the interest at 5 per cent upon the capital ($2,203,673) invested, equals $589,511, the total farm operating expenses. In prorating these expenses, 86.9 per cent of the total expenditures of $589,511 equals $512,285, the amount of the total operating expenses chargeable to cotton.

**TABLE XXVII.**—*Cost of producing cotton on 160 farms operated by white owners (Sumter County, Ga.).*

| | |
|---|---|
| Number of acres in cotton | 14,301 |
| Number of pounds of lint cotton produced | 4,014,500 |
| Total farm receipts | $655,526 |
| Receipts from sale of lint cotton | $496,950 |
| Receipts from sale of cotton seed | 72,701 |
| Receipts from sale of lint cotton and seed | 569,651 |
| Per cent lint cotton and seed sales are of total farm receipts | 86.9 |
| General expenses (labor, feed, seed, fertilizer, insurance, taxes, etc.) | $408,876 |
| Value of farmer's own labor | 70,451 |
| Interest on investment (5 per cent of $2,203,673) | 110,184 |
| Total operating expense | 589,511 |
| Amount of operating expense chargeable to cotton (86.9 per cent of $589,511) | 512,285 |
| Less receipts from sale of cotton seed | 72,701 |
| Net cotton expense, or cost of production of lint | 439,584 |
| Cost per acre of cotton | $30.74 |
| Cost per pound of lint | $0.1095 |

From this expense was deducted $72,701, the amount received from the sale of cotton seed, and the remainder equals $439,584, the expense chargeable to the production of lint cotton. This total divided by the number of acres in cotton gives a cost of $30.74 per acre, which divided by the yield per acre in pounds of lint cotton gives 10.95 cents as the cost per pound of lint.

### DISTRIBUTION OF COSTS.

The items that go to make up the cost of producing cotton have been separated into four groups: Labor, use of land, fertilizer, and miscellaneous. In Table XXVIII is given the distribution of costs on 268 farms operated by white owners.

**TABLE XXVIII.**—*Distribution of costs on 268 farms operated by white owners, owners additional, and owners with part rented out.*

| Item of cost. | Cost per acre. | Per cent of total cost. | Cost per pound of lint (cents). |
|---|---|---|---|
| Labor | $14.58 | 48.4 | 5.22 |
| Use of land | 6.52 | 21.7 | 2.34 |
| Fertilizer | 5.36 | 17.8 | 1.92 |
| Miscellaneous | 3.63 | 12.1 | 1.30 |
| Total | 30.09 | .......... | 10.78 |

The value of labor was the largest single cost connected with growing cotton. It included all labor performed on the crop by wage hands, share croppers, and the operator or members of his family. The labor cost was $14.58 per acre, or 5.22 cents per pound of lint produced.

The expense for the use of the land was second in importance. It included the cost of repairs, depreciation, taxes, insurance, and interest upon the real estate investment. The cost was $6.52 per acre of cotton, or 2.34 cents per pound of lint.

The item next in importance was that for the fertilizer purchased. It was $5.36 per acre, or 1.92 cents per pound of lint cotton.

All the other costs connected with the production of this crop were grouped under one heading as miscellaneous. There were included such items as interest and depreciation on mules and machinery, ginning, and other minor items, and amounted to $3.63 per acre, or 1.3 cents per pound of lint produced.

### COST OF PRODUCTION UNDER VARIOUS TENURES.

Table XXIX shows the cost of producing cotton both per acre and per pound of lint under the various tenures in vogue in Sumter County. In five of the eight tenure classes the cost of production of lint cotton falls within a range of from 10.29 cents to 10.95 cents per pound of lint, or a variation of only 0.66 cent. The cost for all tenures is 10.5 cents per pound and $27.71 per acre.

TABLE XXIX.—*Cost of producing cotton, all tenures, 534 farms, Sumter County, Ga.*

| Tenure. | Number of farms. | Tilled area per farm. | Area in cotton per farm. | Per cent of tilled area in cotton. | Yield of cotton per acre in pounds. | Cost of producing cotton per acre. | Cost of producing cotton per pound (lint). |
|---|---|---|---|---|---|---|---|
| White: | | | | | | | Cents. |
| Owners | 160 | 158 | 89 | 56.6 | 281 | $30.74 | 10.9 |
| Owners additional | 38 | 211 | 96 | 57.4 | 285 | 27.57 | 9.6 |
| Owner's part rented out | 70 | 394 | 133 | 56.9 | 271 | 29.97 | 1 |
| Tenants | 49 | 85 | 54 | 63.3 | 228 | 23.79 | 10. |
| Colored: | | | | | | | |
| Owners | 12 | 95 | 57 | 59.8 | 203 | 20.80 | 10.2 |
| Owners additional | 11 | 82 | 49 | 63.5 | 218 | 20.20 | 9. |
| Owners part rented out | 8 | 307 | 101 | 62.1 | 168 | 19.39 | 11. |
| Tenants | 186 | 59 | 39 | 65.5 | 211 | 22.48 | 10. |

In a study of the three tenures with abnormal costs the factors making up these abnormalities are easily detected. The colored owners with part rented out have a cost of 11.5 cents per pound, with a yield of only 168 pounds per acre. This high cost per pound is almost entirely due to low yields per acre, for when farms in this class are compared with farms of equal yields in the colored-owner class the variation in cost per pound almost disappears. The fact that 38 per cent of the cotton area on the owner-part-rented-out farms returned poor yields makes their yield per acre lower and their cost per pound higher than that of the owner farms with only 27 per cent of their cotton area returning poor yields.

The white owners renting additional land have a lower cost per pound and a slightly higher yield per acre than any other class of white operators. The table shows they have reduced the cost per acre $3.14 and the cost per pound 1.28 cents below that of the white owners. A more detailed study shows this reduction mainly and almost equally due to two items: First, the labor expense per acre of cotton is about $1.50 per acre less; second, the combined charge of interest on capital and rent paid for additional land is over $1.50 less per acre of cotton than the interest charge on the white owners' capital.

We find the colored owners additional occupying the same position among the colored operators as the white owners additional among the white operators, having the lowest cost per pound and the highest yield per acre. They produce their cotton at 1.03 cents per pound less than the colored owners. This difference is accounted for by a yield of 15 pounds more per acre and by a little lower labor cost per acre.

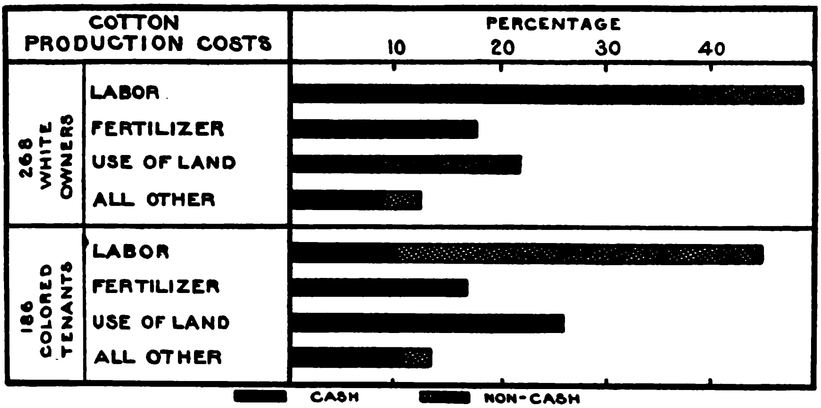

FIG. 6.—Distribution of cash and non-cash costs in producing cotton on 268 owner and 186 tenant farms. (Sumter County, Ga.)

The accompanying chart (fig. 6) is interesting in connection with this cost of production study. The production of lint cotton at 10.5 cents per pound with a yield of 258 pounds per acre means that these men have been well paid for their year's labor and have received a fair rate of interest upon their investment. In case of a lean year cotton could be sold at a figure less than this cost, but it would return less than normal wages for labor performed by the operator and his family and less than a normal interest rate upon the farm investment.

The figure shows the distribution of cost of producing cotton on the owner and tenant farms and the proportion of the cost that was cash and that was noncash. On the owner farms about one-third of the labor was performed by the operator and his family, thus making the cash outlay for labor 36.2 per cent of the total cost. The expense for the use of the real estate was only about one-third cash outlay. The taxes, insurance, and repairs must be met each year, but the other two-thirds of this expense represent the interest charge, which was not cash outlay. The profits these farmers may realize for the use of the land will vary from year to year, depending upon the yields and prices they are able to secure for this crop. The cost of fertilizer represents an expense that must be met each year, and under normal conditions it will equal about one-sixth of the total expense. A portion of the miscellaneous expenses was not cash. About one-fourth of these expenses was for interest and depreciation upon working capital while the other portion was a cash outlay.

In summing up the cost of cotton production upon these owner farms, about 32 per cent of the total was for labor of the operator and his family and interest and depreciation upon the investment. The other 68 per cent was cash paid out for the production of this crop and amounted to 7.35 cents per pound of lint.

In case of the tenants, about 37 per cent was for the labor of the operator and his family and interest upon his working capital and 63 per cent, or 6.70 cents per pound, was cash outlay.

### SIZE OF FARM AND YIELD OF COTTON AS FACTORS AFFECTING THE COST OF PRODUCTION.

The table following (Table XXXI) shows the effect of both size of farm and yield per acre upon the cost of production. If we arrange the farms in size groups there is a gradual decrease in the cost of production per pound of lint from the smallest-size group up to the largest-size group, and when the farms are arranged in yield of cotton per acre groups there is also a decrease in the cost of production of lint per pound from the lowest-yield group up to the highest-yield group. This indicates that both size of farm and yield per acre have some effect in reducing the cost per pound of lint. But when the farms are grouped by size of farm the groups are not all uniform in yield per acre, and when they are grouped by yield per acre the groups are not all uniform in size of farm. Therefore in order to eliminate one of these factors while studying the other, the farms have been grouped according to their size, and each size group separated into subgroups according to their yields per acre. We may now study the effect of size of farm upon the cost of production by comparing the farms of different sizes with the same yield per acre and the effect of yield per acre by comparing the farms of different yields but of the same size.

**Table XXXI.**—*Relation of size of farm and yield of cotton per acre to cost of producing cotton on 268 farms operated by white owners, owners additional, and owners part rented out (Sumter County, Ga.).*

| Size of farm. | One-half bale and less. | | One-half to two-thirds bale. | | Over two-thirds bale. | | All yields. | |
|---|---|---|---|---|---|---|---|---|
| | Cost per acre. | Cost per pound lint. | Cost per acre. | Cost per pound lint. | Cost per acre. | Cost per pound lint. | Cost per acre. | Cost per pound lint. |
| | | *Cents.* | | *Cents.* | | *Cents.* | | *Cents.* |
| 100 acres and less | $29.09 | 13.84 | $34.76 | 11.97 | $41.76 | 10.58 | $34.64 | 12.05 |
| 101 to 250 acres | 25.54 | 12.41 | 31.69 | 11.05 | 37.75 | 9.52 | 31.33 | 10.84 |
| Over 250 acres | 23.58 | 12.27 | 30.28 | 10.10 | 34.33 | 9.52 | 28.72 | 10.52 |
| All sizes | 24.73 | 12.50 | 31.07 | 10.53 | 36.31 | 9.65 | 30.09 | 10.78 |

### THE EFFECT OF SIZE OF FARM UPON COST OF PRODUCING COTTON.

In a study of Table XXXI it will be observed that the very large farms had an advantage over the very small farms in producing cotton at a minimum cost. Many of the farms in each size group also had opportunity to reduce the cost by increasing their yield per acre, as shown when each size group was classified into three yield-per-acre groups.

When the yield per acre was one-half bale and less, the cost per pound of lint cotton was 13.84 cents on farms of 100 acres and less, and as the size of farm increased there was a gradual decrease in this cost. The larger farms with this yield had a cost of 12.27 cents, which was 1.5 cents per pound less than the cost on the small farms.

When the yield per acre was one-half to two-thirds of a bale the cost per pound of lint was 11.97 cents on the small farms, 11.05 cents on the farms of medium size, and 10.10 cents on the large farms. Here the large farms produced cotton at 1.87 cents per pound less than the small farms.

When the yield was over two-thirds of a bale the cost per pound of lint was 10.58 cents on the small farms and 9.52 cents on the medium-sized and large farms. This shows the large farms produced cotton at 1.06 cents less than the small farms.

By carrying the study a little further it will be seen that the cost per pound on the medium-sized farms was 1.43 cents, 0.92 cent and 1.06 cents less in the respective yield-per-acre groups than on the small farms, and that on the large farms this difference was 0.14 cent, 0.95 cent, and zero, as compared with the medium-sized farms. Thus, on the medium-sized farms the cost per pound was something over 1 cent less than on the small farms, while on the large farms it was only 0.32 cent less than on the medium-sized farms.

When we study the cost of cotton per acre, we find the low-yielding group showed a cost of $29.09 on the small-size, $25.54 on the medium-size, and $23.58 on the large-size farms; which was $5.51 less on the large farms than on the small farms. In the yield-per-acre group of one-half to two-thirds bale the cost was $34.76 on the small farms, $31.69 on farms of medium size, and $30.28 on farms of over 250 acres, which was $4.48 less on the large farms than on the small farms.

On the farms with the highest yields of cotton the cost per acre was $41.76 in the group with 100 acres and less, and then as the size of farm increased the cost decreased until in the largest-size group it was $34.33 per acre. This was $7.43 less on the large farms than on the small farms.

There was a greater reduction in the cost per acre between the small and the medium farms than between the medium and large farms. The reduction in favor of the medium-size group over the smallest-size group was $3.55, $3.07, and $4.01 in the respective yield-per-acre groups, while the reduction in favor of the largest-size group over the medium-size group was only $1.96, $1.41, and $3.42 in the respective yield-per-acre groups.

### THE EFFECT OF YIELD PER ACRE UPON THE COST OF PRODUCTION.

In Table XXXI the farms are separated into three groups that may be used in studying the effect of yield per acre upon the cost of production.

On farms with 100 or less acres the cost per pound of lint cotton was 13.84 cents when the yield was one-half bale, 11.97 cents when the yield was from one-half to two-thirds bale, and 10.58 cents when the yield was over two-thirds bale. This shows the cost per pound 3.26 cents less on the good than on the poor yielding farms.

On farms of 101 to 250 acres the cost per pound of lint was 12.41 cents when the yield was poor, 11.05 cents with a medium yield, and 9.52 cents when the yield was good. This shows the cost per pound 2.89 cents less on the good than on the poor yielding farms.

On the farms of over 250 acres the cost per pound of lint was 12.27 cents when the yield was poor, 10.10 cents when the yield was from one-half to two-thirds of a bale, and 9.52 cents when the yield was good. This shows the cost per pound 2.75 cents less on the good than on the poor yielding farms.

Thus in the respective size groups cotton was produced at 3.26 cents, 2.89 cents, and 2.75 cents per pound less on the farms having good yields than on the farms having poor yields.

With medium yields per acre the cost per pound was 1.87 cents, 1.36 cents, and 2.17 cents less for the respective size groups than with poor yields, but with good yields the cost per pound was only 1.39 cents, 1.53 cents, and 0.58 cent less for the respective size groups than with medium yields. The cost was almost 2 cents per pound less with medium yields than with poor yields and about 1 cent per pound less with good yields than with medium yields.

The table shows that the cost of cotton per acre was increased as the yield per acre increased. On the smallest farms the cost was $29.09 when the yield was poor, $34.76 when the yield was medium, and $41.76 on the good yielding farms.

On the medium-size farms the cost per acre was $25.54 when the yield was poor, $31.69 when the yield was medium, and $37.75 when the yield was good.

On the very large farms the cost per acre was $23.58 when the yield was poor, $30.28 when the yield was medium, and $34.33 when the yield was good.

Thus with a medium yield the cost per acre was $5.67, $6.15, and $6.70 more in the respective size groups than when the yield was poor, and with good yields the cost per acre was $7, $6.07, and $4.05 more in the respective size groups than with medium yields.

## THE COST OF PRODUCTION ON THE COLORED-TENANT FARMS.

Table XXXII shows the effect of the size of farm and yield of cotton per acre upon the cost of production on the farms operated by colored tenants. While the yields these tenants received were much lower than those of the other farmers, the wide variation in yields gives room for comparisons in the same manner upon these farms as upon others. In order to have a satisfactory number of farms in each group these farms were used in two size groups, those with 50 acres or less and those with over 50 acres. Each of the size groups was then divided into three yield-per-acre groups. With yields of one-third bale or less per acre the cost per pound of lint was 14.39 cents on the small farms and 12.80 cents on the larger farms; with yields of one-third to one-half bale per acre the cost per pound was 11.61 cents on the small farms and 10.22 cents on the larger farms; and with the yields of over one-half bale the cost per pound was 9.36 cents on the small farms and 8.93 cents on the larger farms.

TABLE XXXII.—*Relation of size of farm and yield of cotton per acre to cost of producing cotton on 186 farms operated by colored tenants (Sumter County, Ga.).*

| Size of farm. | One - third bale and less. | | One-third to one-half bale. | | Over one-half bale. | | All yields. | |
|---|---|---|---|---|---|---|---|---|
| | Cost per acre. | Cost per pound lint. | Cost per acre. | Cost per pound lint. | Cost per acre. | Cost per pound lint. | Cost per acre | Cost per pound lint. |
| | | *Cents.* | | *Cents.* | | *Cents.* | | *Cents.* |
| 50 acres and less | $19.93 | 14.39 | $24.15 | 11.61 | $28.61 | 9.36 | $23.59 | 11.68 |
| Over 50 acres | 18.26 | 12.80 | 22.22 | 10.22 | 25.40 | 8.93 | 21.99 | 10.21 |
| All sizes | 18.99 | 13.48 | 22.71 | 10.57 | 26.30 | 9.06 | 22.49 | 10.64 |

Thus on farms of over 50 acres the cost per pound of lint was 1.59 cents, 1.39 cents, and 0.43 cent less in the respective yield-per-acre groups than on farms of less than 50 acres.

The cost per acre was also less in each yield-per-acre group on the farms of over 50 acres than on the farms of 50 acres or less, being $1.67, $1.93, and $3.21 less in the respective yield-per-acre groups.

In a study of the effect of yields per acre upon reducing the cost of production, the outstanding factor of size must be given consideration. On farms of 50 acres and less the cost was 14.39 cents when the yield was one-third bale and less, 11.61 cents when the yield was one-third to one-half bale, and 9.36 cents when the yield was over one-half bale.

On the farms of over 50 acres the cost was 12.8 cents when the yield was one-third and less, 10.22 cents when the yield was one-third to one-half bale, and 8.93 cents when the yield was over one-half bale.

Thus with the yield of cotton one-third to one-half bale it was produced at 2.78 cents per pound less than with the yield one-third bale and less on farms of 50 acres and less, and at 2.58 cents less on farms of over 50 acres. With the yield over one-half bale, it was produced at 2.85 cents per pound less than with the yield one-third to one-half bale on farms of 50 acres and less, and at 1.29 cents less on farms of over 50 acres.

The cost per acre on small farms was $19.93 when the yield was one-third bale and less, $24.15 when the yield was one-third to one-half bale, and $28.61 when the yield was over one-half bale. On the larger farms it was $18.26 when the yield was one-third bale and less, $22.22 when the yield was one-third to one-half bale, and $25.40 when the yield was over one-half bale.

The increase in cost per acre for the groups yielding one-third to one-half bale over that of the groups yielding one-third bale or less was $4.22 on farms of 50 acres and less, and $3.96 on farms of over 50 acres.

The increase in cost per acre for the farms yielding over one-half bale over that of the farms yielding one-third to one-half bale was $4.46 for the smallest and $3.18 for the largest size group.

On all the colored tenant farms with yields of one-third bale or less, the cost per acre was $18.99, and on all with yields of over one-half bale the cost per acre was $26.30, or an increase of $7.31. The main items in this increase are labor and fertilizer.

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UNITED STATES DEPARTMENT OF AGRICULTURE

**BULLETIN No. 493**

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CARL L. ALSBERG, Chief

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# A STUDY OF AMERICAN BEERS AND ALES.

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## INTRODUCTION.

The investigation, the results of which are reported in this bulletin, was undertaken for the purpose of securing information in regard to the composition of brewery products made in this country. The main object of this investigation was to find, if possible, a means of distinguishing beers and ales made entirely from malt from those made from malt together with other cereal products, such as rice, corn, and cerealin.

It was concluded, after looking into the literature, that in order to accomplish this purpose it would be necessary to collect a series of samples made from the various raw materials ordinarily used and make a study of the effect of these raw materials upon the composition of the finished product.

The investigation seemed desirable for the reason that practically all of the existing data related to foreign beers, in the preparation of which a type of malt was used entirely different from that ordinarily used in the production of American beers. Furthermore, very few of the existing data relating either to foreign or domestic beers were based upon samples concerning which exact information was available in regard to the raw materials used in the wort.

## METHOD OF UNDERTAKING THE INVESTIGATION.

It was felt that it would be wholly unsatisfactory to make this investigation by means of laboratory brewings on a small scale, as the results thus obtained would not show the true conditions, because it is not possible in the laboratory to duplicate exactly the mashing or fermenting processes actually used in a commercial way. It was decided, therefore, to attempt, with the cooperation of several breweries, to make this study under the exact conditions prevailing in commercial plants. Access was secured to several breweries making different types of products from various kinds of raw materials, under such conditions that it was possible to obtain a complete history of the beer through its various stages to the finished product. One of the writers (Riley) watched the method of manufacture during its whole process and obtained samples of the product at the various stages of manufacture. Thus, it was possible to procure finished samples with practically the same degree of certainty, as regards knowledge of composition and history, as would have been the case had they been prepared in the laboratory.

In three different breweries manufacturing a wide range of products samples of the wort and beer were obtained in this manner, the entire process of manufacture being studied in detail. A record showing the kind and amount of raw materials placed in the mash and in the cooker was made of the samples collected from these three breweries. A record also was kept of the time and temperature of each operation until the mash was ready to run into the kettle. The filtering and sparging [1] of the mash, the time of boiling in the kettle, the amount of hops added and the point at which they were added, and the break [2] of the wort were all noted. After the wort had been pumped from the kettle its course was followed through the hop jack [3] over the coolers to the settling tank. The specific gravity or Balling [4] of the original wort, the temperature at which the product was pitched,[5] the aeration of the wort, the kind and amount of yeast added, as well as the time and maximum temperature of the primary fermentation, also were noted. The course of the beer through the storage vats, chip casks, and filters to the racks was watched, and samples of the wort and of the beer in its various stages of production were collected and examined.

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[1] Washing the grains with hot water to remove the extract or valuable constituents as completely as possible.

[2] Precipitation and uniting, in the form of flakes, of the coagulable albuminoids, leaving the liquid clear.

[3] A filtering tank.

[4] Percentage of solids in the liquor according to the Balling hydrometer.

[5] Pitching is the operation of adding the yeast to the wort.

## METHODS OF ANALYSIS.

The methods of analysis used were those given in Bulletin 107, revised (U. S. Dept. Agr., Bur. Chem.), pages 90–94, with the exception that the determination of phosphoric acid was made by the method used in fertilizer analysis (ibid., pp. 2–5), destroying the organic material in the beer by digestion with strong sulphuric acid and nitric acid and determining the phosphoric acid finally by the optional volumetric method (ibid., p. 4). The uranium acetate method given for beers was not used, for the reason that it was found to be exceedingly difficult to obtain accurate results on dark-colored beers.[1]

It was found in the estimation of dextrin by the Sachsse-Allihn method (ibid., p. 91) that there is an error in the method of calculation of the amount of dextrose formed from the amount of maltose in the original beer. Instead of multiplying the amount of maltose in the original beer by the factor 0.9, it should be multiplied by the factor 1.053, as 1 gram of anhydrous maltose yields, on hydrolysis, 1.053 grams of dextrose. The product is the quantity which should be subtracted from the total amount of dextrose found after hydrolysis. The extract in the beer was determined by use of the tables of Schultz and Ostermann (ibid., pp. 209–213). The same methods were used in the analyses of the worts as were used in the examination of the beers.

## RESULTS OF ANALYSIS.

Tables I to IV contain the results of the analyses of the worts and finished fermented products obtained at the various breweries where this investigation was conducted, arranged so as to show readily the changes which took place during fermentation and, in a few cases, the changes which took place during storage. The results are all given in terms of grams per 100 cc, so that a direct comparison of the quantities of any particular ingredient in a definite volume of material may be made. The comparison of the grams per 100 cc of an ingredient in the wort, with the grams per 100 cc in the finished fermented product, is based on the assumption that there is no appreciable change in the volume of the wort during fermentation.

In Table I are given the results of the analyses of 7 malt worts and the beers produced from them. Table II contains the results of the analyses of 2 malt-and-rice worts and 2 malt-and-corn worts, and the beers produced from them. In Table III are given the results of the analyses of 4 porter worts and the finished porters produced from them. The results of the analyses of 9 ale worts and the finished ales are shown in Table IV. In these four tables the extract in the original wort has been calculated by multiplying the alcohol (expressed in terms of grams per 100 cc) by 2, and adding to the product the extract of the beer, porter, or ale (expressed in terms of grams per 100 cc). In the porter and ale worts a percentage of dextrose had been added as brewer's sugar. Since dextrose reduces more copper than does maltose in the determination of the sugars, in order to obtain the true percentage of total sugars it was necessary to calculate the amount of copper reduced by the known amount of dextrose present, and then to calculate the amount of maltose. The results thus obtained are given in Tables III and IV under the heading "Reducing sugars as anhydrous maltose."

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[1] Riley, in his report to the Association of Official Agricultural Chemists for the year 1913, stated that the method giving the most uniform results was that of ashing the beer with an excess of standard calcium acetate, and that while the moist combustion method in the hands of those familiar with it gave satisfactory results, the various collaborators working with the method did not get as uniform results as with the method of ashing with calcium acetate. J. Assoc. Off. Agr. Chemists 1 (1915), 138–143.

TABLE I.—*Analyses of all-malt worts and of the beers made from them.*

| Sample No. | Product. | Date of taking sample. | Specific gravity at 15.6° C./15.6° C. | Alcohol. | Extract. | Extract in original wort (calculated). | Degree of fermentation. | Total acids as lactic. | Volatile acids as acetic. | Reducing sugar as anhydrous maltose. | Dextrin. | Protein (N×6.25). | Ash. | Phosphoric acid (as $P_2O_5$). | Undetermined. | Color (Lovibond) in ½-inch cell. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | 1911. |  | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* |  | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Degrees, brewer's scale.* |
| 22013-D | Wort.... | July 5 | 1.0518 |  | 13.75 |  |  | 0.198 | 0.001 | 9.79 |  | 0.862 | 0.231 | 0.098 |  | 13.0 |
| 22017-D | Beer.... | July 12 | 1.0125 | 3.85 | 5.16 | 12.86 | 59.88 | .216 | .001 | 1.34 | 2.33 | .611 | .209 | .080 | 0.67 | 12.0 |
| 22014-D | Wort.... | July 6 | 1.0517 |  | 13.71 |  |  | .198 | .001 | 9.79 |  | .876 | .228 | .095 |  | 13.0 |
| 22018-D | Beer.... | July 13 | 1.0124 | 3.91 | 5.16 | 12.98 | 60.25 | .225 | .002 | 1.36 | 2.06 | .614 | .201 | .078 | .93 | 13.0 |
|  | Wort.... | July 7 | 1.0517 |  | 13.71 |  |  | .207 | .001 | 10.04 |  | .852 | .252 | .099 |  | 13.0 |
| 22019-D | Beer.... | July 14 | 1.0135 | 3.83 | 5.44 | 13.10 | 58.47 | .234 | .002 | 1.55 |  | .610 | .215 | .082 |  | 9.0 |
| 22015-D | Wort.... | July 8 | 1.0517 |  | 13.70 |  |  | .198 | .001 | 9.86 |  | .841 | .240 | .097 |  | 13.0 |
| 22020-D | Beer.... | July 15 | 1.0130 | 3.72 | 5.22 | 12.66 | 58.77 | .236 | .002 | 1.59 | 2.23 | .639 | .206 | .081 | .55 | 11.0 |
| 22016-D | Wort.... | July 10 | 1.0515 |  | 13.68 |  |  | .225 | .001 | 9.84 |  | .845 | .245 | .097 |  | 13.0 |
| 22021-D | Beer.... | July 17 | 1.0147 | 3.66 | 5.66 | 12.98 | 56.39 | .221 | .001 | 1.85 | 2.18 | .635 | .208 | .082 | .78 | 10.0 |
| 16289-C | Wort.... | 1912.<br>Feb. 29 | 1.0455 |  | 12.05 |  |  | .216 | .001 | 7.40 |  | .917 | .232 | .095 |  | 4.0 |
| 16289-C | Beer.... | Mar. 7 | 1.0171 | 3.02 | 6.01 | 12.11 | 49.88 | .230 | .003 | 1.35 | 2.73 | .757 | .246 | .082 | .83 | 3.0 |
| 20714-D | Do.... | Apr. 18 | 1.0167 | 3.12 | 5.90 | 12.14 | 51.40 | .243 | .012 | 1.47 | 2.68 | .732 | .229 | .090 | .79 | 3.0 |
| 16299-C | Wort.... | Mar. 1 | 1.0454 |  | 12.02 |  |  | .180 | .001 | 7.41 |  | .874 | .238 | .101 |  | 2.0 |
| 16299-C | Beer.... | Mar. 18 | 1.0180 | 2.87 | 6.16 | 11.94 | 48.07 | .234 | .012 | 1.40 | 2.82 | .737 | .240 | .090 | .96 | 2.0 |

TABLE II.—*Analyses of malt-and-rice and malt-and-corn worts and of the beers made from them.*

| Sample No. | Raw materials. | Product. | Date of taking sample. | Specific gravity at 15.6° C./15.6° C. | Alcohol. | Extract. | Extract in original wort (calculated). | Degree of fermentation. | Total acids as lactic. | Volatile acids as acetic. | Reducing sugars as anhydrous maltose. | Dextrin. | Protein (N× 6.25). | Ash. | Phosphoric acid (as $P_2O_5$). | Undetermined. | Color (Lovibond) in ½-inch cell. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Degrees, brewer's scale.* |
| 22026-D | 80 per cent malt and 20 per cent rice. | Wort.... | July 24, 1911 | 1.0459 | ........ | 12.15 | ........ | ........ | 0.124 | 0.001 | 8.64 | ........ | 0.714 | 0.193 | 0.069 | ........ | 2.0 |
| 22032-D | Do................ | Beer.... | July 31, 1911 | 1.0121 | 3.31 | 4.80 | 11.42 | 57.97 | .275 | .003 | 1.18 | 2.47 | .519 | .150 | .055 | 0.48 | 2.0 |
| 22036-D | Do................ | Wort.... | Aug. 9, 1911 | 1.0464 | ........ | 12.30 | ........ | ........ | .126 | .001 | 8.70 | ........ | .624 | .204 | .072 | ........ | 2.0 |
| 22042-D | Do................ | Beer.... | Aug. 16, 1911 | 1.0139 | 3.18 | 5.23 | 11.59 | 54.87 | .243 | .003 | 1.57 | 2.41 | .400 | .156 | .057 | .69 | 2.0 |
| 16269-C | 60 per cent malt and 40 per cent corn. | Wort.... | Dec. 5, 1911 | 1.0489 | ........ | 12.95 | ........ | ........ | .144 | .003 | 9.05 | ........ | .461 | .229 | .066 | ........ | ........ |
| 16271-C | Do................ | Beer.... | Dec. 12, 1911 | 1.0149 | 3.45 | 5.68 | 12.58 | 54.85 | .171 | .013 | 1.63 | 2.49 | .308 | .213 | .056 | 1.04 | ........ |
| 16287-C | Do................ | ...do..... | Mar. 12, 1912 | 1.0159 | 3.33 | 5.76 | 12.42 | 53.62 | .180 | .014 | 1.87 | 2.36 | .327 | .208 | .056 | .99 | ........ |
| 16270-C | Do................ | Wort.... | Dec. 6, 1911 | 1.0496 | ........ | 13.14 | ........ | ........ | .144 | .003 | 9.32 | ........ | .498 | .216 | .067 | ........ | ........ |
| 16272-C | Do................ | Beer.... | Dec. 13, 1911 | 1.0152 | 3.41 | 5.61 | 12.43 | 54.87 | .171 | .013 | 1.59 | 2.58 | .314 | .203 | .050 | .93 | ........ |
| 16286-C | Do................ | ...do..... | Mar. 12, 1912 | 1.0157 | 3.29 | 5.68 | 12.26 | 53.67 | .175 | .014 | 1.88 | 2.58 | .314 | .222 | .058 | .69 | ........ |

TABLE III.—*Analyses of porter worts made from malt, cerealin, and brewer's sugar, and of the porters made from these worts.*

| Sample No. | Product. | Date of taking sample. | Specific gravity at 15.6° C./15.6° C. | Alcohol. | Extract. | Extract in original wort (calculated). | Degree of fermentation. | Total acids as lactic. | Volatile acids as acetic. | Reducing sugars as anhydrous maltose. | Dextrin. | Protein (N×6.25) | Ash. | Phosphoric acid (as $P_2O_5$). | Undetermined. | Color (Lovibond) in ½-inch cell. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1911. | | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Degrees, brewer's scale.* |
| 22023-D | Wort........ | July 20 | 1.0572 | .......... | 15.25 | .......... | ........ | 0.270 | 0.002 | 8.67 | .......... | 0.696 | 0.227 | 0.069 | .......... | 58.0 |
| 22028-D | Porter...... | July 26 | 1.0151 | 4.30 | 6.02 | 14.62 | 58.82 | .324 | .003 | 1.07 | 3.34 | .482 | .208 | .052 | 0.92 | 59.0 |
| 22046-D | .....do...... | Aug. 21 | 1.0135 | 4.48 | 5.70 | 14.66 | 61.12 | .380 | .002 | 1.07 | 3.19 | .482 | .182 | .051 | .78 | 60.0 |
| 22038-D | Wort........ | Aug. 11 | 1.0625 | .......... | 16.66 | .......... | ........ | .234 | .002 | 9.74 | .......... | .685 | .232 | .072 | .......... | 65.0 |
| 22044-D | Porter...... | Aug. 18 | 1.0165 | 4.75 | 6.60 | 16.10 | 59.01 | .342 | .002 | 1.42 | 3.48 | .477 | .196 | .053 | 1.02 | 60.0 |
| 22045-D | Wort........ | Aug. 18 | 1.0623 | .......... | 16.62 | .......... | ........ | .234 | .002 | 9.68 | .......... | .667 | .224 | .069 | .......... | 55.0 |
| 29501-B | Porter...... | Aug. 25 | 1.0170 | 4.72 | 6.72 | 16.16 | 58.42 | .288 | .002 | 1.41 | 3.62 | .482 | .201 | .058 | 1.01 | 55.0 |
| 22025-D | Wort........ | July 21 | 1.0633 | .......... | 16.87 | .......... | ........ | .234 | .004 | 10.25 | .......... | .721 | .214 | .073 | .......... | 70.0 |
| 22031-D | Porter...... | July 28 | 1.0178 | 4.70 | 6.96 | 16.36 | 57.46 | .378 | .002 | 1.40 | 3.68 | .476 | .194 | .055 | 1.21 | 60.0 |
| 22049-D | .....do...... | Aug. 24 | 1.0162 | 4.82 | 6.54 | 16.18 | 59.58 | .306 | .003 | 1.44 | 3.44 | .479 | .189 | .053 | .99 | 60.0 |

TABLE IV.—*Analyses of ale worts and of the ales made from them.*

| Sample No. | Raw materials. | Product. | Date of taking sample. | Specific gravity at 15.6° C./15.6° C. | Alcohol. | Extract. | Extract in original wort (calculated). | Degree of fermentation. | Total acids as lactic. | Volatile acids as acetic. | Reducing sugars as anhydrous maltose. | Dextrin. | Protein (N× 6.25). | Ash. | Phosphoric acid (as $P_2O_5$). | Undetermined | Color (Lovibond) in ½-inch cell. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | *Degrees, brewer's scale.* |
| 22024-D | Malt, cerealin, and brewer's sugar. | Wort..... | 1911.<br>July 21 | 1.0608 | ........ | 16.24 | ........ | ........ | 0.153 | 0.001 | 10.00 | ........ | 0.788 | 0.230 | 0.059 | ........ | 4.0 |
| 22030-D | .....do.................. | Ale...... | July 27 | 1.0139 | 4.82 | 5.93 | 15.57 | 61.91 | .225 | .003 | 1.16 | 3.23 | .425 | .194 | .039 | 0.92 | 5.0 |
| 22047-D | .....do.................. | Ale after storage. | Aug. 22 | 1.0124 | 4.97 | 5.62 | 15.56 | 63.88 | .270 | .003 | 1.43 | 2.60 | .441 | .180 | .038 | .88 | 5.0 |
| 22034-D | .....do.................. | Wort..... | Aug. 7 | 1.0610 | ........ | 16.30 | ........ | ........ | .153 | .003 | 10.24 | ........ | .771 | .214 | .060 | ........ | 5.0 |
| 22039-D | .....do.................. | Ale...... | Aug. 14 | 1.0123 | 5.11 | 5.67 | 15.89 | 64.32 | .225 | .003 | 1.26 | 2.85 | .471 | .186 | .043 | .90 | 5.0 |
| 29504-B | .....do.................. | Ale after storage. | Oct. 6 | 1.0106 | 5.26 | 5.28 | 15.80 | 66.58 | .225 | .003 | 1.10 | 2.60 | .462 | .189 | .041 | .93 | 5.0 |
| 22037-D | .....do.................. | Wort..... | Aug. 10 | 1.0611 | ........ | 16.32 | ........ | ........ | .149 | .002 | 10.60 | ........ | .763 | .209 | .057 | ........ | 4.0 |
| 22043-D | .....do.................. | Ale...... | Aug. 17 | 1.0124 | 4.93 | 5.62 | 15.48 | 63.69 | .216 | .003 | 1.40 | 2.82 | .441 | .172 | .043 | .79 | 4.0 |
| 22022-D | Malt and cerealin...... | Wort..... | July 19 | 1.0642 | ........ | 17.10 | ........ | ........ | .180 | .002 | 10.19 | ........ | .776 | .212 | .072 | ........ | 3.0 |
| 22027-D | .....do.................. | Ale...... | July 26 | 1.0133 | 5.17 | 5.95 | 16.29 | 63.47 | .207 | .004 | 1.25 | 3.28 | .500 | .192 | .055 | .73 | 3.0 |
| 22035-D | .....do.................. | Wort..... | Aug. 5 | 1.0668 | ........ | 17.80 | ........ | ........ | .189 | .002 | 10.99 | ........ | .776 | .212 | .072 | ........ | 3.0 |
| 22040-D | .....do.................. | Ale...... | Aug. 15 | 1.0145 | 5.34 | 6.30 | 16.98 | 62.90 | .293 | .004 | 1.42 | 3.31 | .541 | .192 | .051 | .84 | 4.0 |
| 16267-C | .....do.................. | Ale after storage. | Nov. 15 | 1.0134 | 5.52 | 6.11 | 17.15 | 64.37 | .234 | .004 | 1.65 | 2.76 | .506 | .213 | .053 | .98 | 3.0 |
| 29506-B | .....do.................. | Wort..... | Oct. 10 | 1.0760 | ........ | 20.23 | ........ | ........ | .198 | .001 | 11.19 | 6.81 | .959 | .294 | .077 | .98 | 3.0 |
| 29512-B | .....do.................. | Ale...... | Oct. 17 | 1.0253 | 5.43 | 9.19 | 20.05 | 54.16 | .369 | .008 | 2.69 | 4.39 | .671 | .273 | .058 | 1.17 | 3.0 |
| 13922-D | .....do.................. | Ale after storage. | 1912.<br>Jan. 3 | 1.0208 | 5.80 | 8.18 | 19.78 | 58.64 | .360 | .008 | 2.54 | 3.42 | .622 | .275 | .057 | 1.32 | 4.0 |
| 29507-B | .....do.................. | Wort..... | 1911.<br>Oct. 11 | 1.0767 | ........ | 20.40 | ........ | ........ | .198 | .001 | 12.14 | 5.59 | .965 | .282 | .078 | 1.42 | 3.0 |
| 29514-B | .....do.................. | Ale...... | Oct. 18 | 1.0228 | 5.67 | 8.52 | 19.86 | 57.10 | .360 | .005 | 2.51 | 4.08 | .664 | .256 | .057 | 1.01 | 2.0 |
| 29513-B | .....do.................. | Wort..... | Oct. 18 | 1.0781 | ........ | 20.75 | ........ | ........ | .198 | .002 | 11.73 | 5.95 | .936 | .300 | .075 | 1.83 | 2.0 |
| 29519-B | .....do.................. | Ale...... | Oct. 24 | 1.0244 | 5.53 | 9.00 | 20.06 | 55.13 | .281 | .006 | 2.62 | 4.31 | .671 | .255 | .057 | 1.14 | 2.0 |
| 13923-D | .....do.................. | Ale after storage. | 1912.<br>Jan. 2 | 1.0210 | 5.67 | 8.18 | 19.52 | 58.09 | .360 | .013 | 2.54 | 3.61 | .603 | .282 | .064 | 1.15 | 4.0 |
| 22060-D | .....do.................. | Wort..... | 1911.<br>Aug. 23 | 1.0793 | ........ | 21.05 | ........ | ........ | .270 | .003 | 11.41 | 6.34 | .864 | .326 | .091 | 2.11 | 75.0 |
| 29508-B | .....do.................. | Stout.... | Aug. 30 | 1.0242 | 5.60 | 9.02 | 20.40 | 55.78 | .558 | .003 | 2.05 | 4.54 | .735 | .286 | .071 | 1.42 | 60.0 |

A study of these tables shows very clearly that during fermentation marked changes are brought about other than the mere conversion of sugar into alcohol. While it is well known that these changes take place it seems worth while to consider them here, because no similar study relating to American brewery products has been published. Further since we have the exact analysis of the wort and of the beer which was made from it, we have a special opportunity to examine quantitatively some of these changes, such as the production of alcohol, the fermentation of dextrin, the development of acids, and the losses of protein, ash, and phosphoric acid during fermentation.

In order to study the question of the yield of alcohol, to test the present factor used for the calculation of the solids in the original wort, and to show the approximate amount of dextrin, calculations were made, the results of which are presented in Table V.

TABLE V.—*Changes taking place in the conversion of worts into beers and ales.*

| Product. | Loss in solids. | Loss in sugar. | Alcohol. | Loss in solids divided by alcohol. | Difference between loss in solids and loss in sugar. |
|---|---|---|---|---|---|
| | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* | | *Grams per 100 cc.* |
| Beer (all-malt) | 8.59 | 8.45 | 3.85 | 2.23 | 0.14 |
| Do | 8.55 | 8.43 | 3.91 | 2.18 | .12 |
| Do | 8.27 | 8.49 | 3.83 | 2.13 | .22 |
| Do | 8.48 | 8.27 | 3.72 | 2.27 | .21 |
| Do | 8.02 | 7.99 | 3.66 | 2.19 | .03 |
| Beer (60 per cent malt and 40 per cent corn) | 7.27 | 7.42 | 3.45 | 2.10 | .15 |
| Do | 7.53 | 7.73 | 3.33 | 2.00 | .20 |
| Beer (80 per cent malt and 20 per cent rice) | 7.35 | 7.46 | 3.31 | 2.22 | .11 |
| Do | 7.07 | 7.13 | 3.18 | 2.22 | .06 |
| Beer (all-malt) | 6.04 | 6.05 | 3.02 | 2.00 | .01 |
| Do | 5.86 | 6.01 | 2.87 | 2.04 | .15 |
| Average for beers | ........ | ........ | ........ | 2.14 | .04 |
| Porter (small) | 9.23 | 7.60 | 4.30 | 2.14 | 1.63 |
| Porter (large) | 9.91 | 8.32 | 4.70 | 2.10 | 1.59 |
| Do | 10.06 | 8.27 | 4.75 | 2.11 | 1.79 |
| Do | 9.90 | 7.82 | 4.72 | 2.09 | 2.08 |
| Ale | 10.31 | 8.84 | 4.82 | 2.13 | 1.47 |
| Do | 10.63 | 8.98 | 5.11 | 2.08 | 1.65 |
| Do | 10.70 | 9.20 | 4.93 | 2.17 | 1.50 |
| Do | 11.15 | 8.94 | 5.16 | 2.15 | 2.21 |
| Do | 11.50 | 9.57 | 5.34 | 2.15 | 1.93 |
| Do | 11.62 | 9.06 | 5.35 | 2.17 | 2.56 |
| Pale ale | 11.04 | 9.50 | 5.43 | 2.03 | 1.54 |
| Do | 11.88 | 9.63 | 5.67 | 2.09 | 2.25 |
| Do | 11.75 | 9.11 | 5.53 | 2.12 | 2.64 |
| Brown stout | 12.03 | 9.38 | 5.69 | 2.11 | 2.65 |
| Average for ales | ........ | ........ | ........ | 2.12 | 1.96 |
| Average for beers and ales | ........ | ........ | ........ | 2.13 | ........ |

In Table V have been collected results (calculated from Tables I–IV) which show the loss in solids between the wort and the finished fermented product, the loss in sugar, the yield of alcohol, the loss in solids divided by the alcohol, and the difference between the loss in solids and the loss in sugar. By dividing alcohol into loss in solids there was secured a factor which makes possible the estimation of the solids in the original wort, provided that alcohol and extract are known. This factor also shows the yield of alcohol for a given amount of solids disappearing during fermentation. It has been found in the case of the beers that this factor averages 2.14, while in the case of the ales it averages 2.12, making an average for all of the products of 2.13. This clearly shows that in the yield of alcohol for a given amount of fermentable solids there is no appreciable difference between top fermentation products, such as ales, and bottom fermentation products, such as beers.

A marked difference in loss in solids is shown, however, when we compare the beers with the ales. In the case of the beers we find there is practically no difference between the loss in solids and the loss in sugar, while in the case of the porters and ales there is a very appreciable difference. The difference between the loss in solids and the loss in sugar is only 0.04 per cent for all of the beers; while in the case of the porters and ales the difference varies from 1.47 per cent to 2.65 per cent, with an average of 1.96 per cent. These figures clearly show that in the case of the porters and ales there has been some material other than sugar fermented. Unfortunately, the determination of dextrin was not made in all of the worts, so that the actual decrease in dextrin can be shown only in a few cases. But in those cases where we have the actual results the difference between loss in solids and the loss in sugar compares very closely with the actual amount of dextrin disappearing during fermentation.

## DEVELOPMENT OF ACIDS DURING FERMENTATION.

A comparison of the amounts of volatile and fixed acids in the worts and in the finished beers shows that normally there is no appreciable development of volatile acid during fermentation and only a slight increase in the fixed acid. This increase in fixed acid averages in the case of the beers 0.049 per cent, while in the case of the ales the increase averages 0.103 per cent.

## DECREASE IN PROTEIN, ASH, AND PHOSPHORIC ACID.

A general study of the preceding tables will show that there is an appreciable loss of protein, ash, and phosphoric acid during the fermentation. Table VI has been prepared to show the average loss during fermentation of the various classes of worts with respect to their protein, ash, and phosphoric acid contents.

TABLE VI.—*Average loss during fermentation.*

| Kind of wort. | Protein. | Ash. | Phosphoric acid. |
|---|---|---|---|
| | *Grams per 100 cc.* | *Grams per 100 cc.* | *Grams per 100 cc.* |
| Beer worts (all-malt) | 0.209 | 0.017 | 0.015 |
| Beer worts (malt and rice) | .210 | .045 | .014 |
| Beer worts (malt and corn) | .168 | .014 | .013 |
| Porter worts | .213 | .031 | .017 |
| Ale worts | .275 | .029 | .019 |

The results given in Table VI show a great similarity in the changes in all of the products, as there is about the same amount of loss of protein, ash, and phosphoric acid in the beer, ale, and porter worts. There does not appear to be any appreciable loss, however, of either protein or phosphoric acid during the storage or aging period as is shown by the few samples which we have analyzed after storage. This is practically in agreement with the experiment of Bertschinger,[1] whose results show only a very slight increase in alcohol and loss of sugar during the storage period.

## EFFECT OF RAW MATERIALS USED UPON COMPOSITION OF THE FINISHED BREW.

In order to show the effects on the finished beers or ales of the use of corn, rice, cerealin, and brewer's sugar as substitutes for malt in the worts, Table VII has been prepared, giving the results of analyses of a number of brews made in different breweries and from varying kinds and amounts of raw materials.

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[1] Z. angew. Chem. (1890), p. 670.

TABLE VII.—*Analyses of beers and ales from various breweries.*

| Sample No. | Raw materials. | Product. | Alcohol. | Extract (Schultz and Ostermann). | Extract in original wort (calculated). | Degree of fermentation. | Total acid as lactic. | Volatile acid as acetic. | Reducing sugars as anhydrous maltose. | Dextrin. | Protein (N × 6.25). | Ash. | Phosphoric acid (as $P_2O_5$.) | Undetermined. | Polarimeter. | Color (Lovibond) in ½-inch cell. | Calculated to basis of wort with 15 per cent solids. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | Protein (N × 6.25). | Ash. | Phosphoric acid (as $P_2O_5$.) |
| | *Brewery No. 1.* | | *P. ct. by wght.* | *P. ct.* | *P. ct.* | | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *Degs. V.* | *Degs.*[1] | *P. ct.* | *P. ct.* | *P. ct.* |
| 14004-H | Malt | Beer | 3.07 | 5.55 | 11.69 | 52.54 | 0.223 | 0.013 | 1.59 | 2.64 | 0.615 | 0.207 | 0.072 | 0.49 | +58.0 | 5 | 0.789 | 0.266 | 0.092 |
| 14005-H | 65 per cent malt and 35 per cent cerealin. | ...do | 2.42 | 6.19 | 11.03 | 43.88 | .142 | .013 | 1.81 | 3.15 | .355 | .141 | .042 | .73 | +50.8 | 3 | .483 | .192 | .057 |
| 14006-H | 60 per cent malt and 40 per cent corn. | ...do | 2.16 | 5.28 | 9.60 | 45.00 | .178 | .007 | 1.52 | 2.96 | .260 | .124 | .039 | .42 | +44.0 | 4 | .407 | .194 | .061 |
| | *Brewery No. 2.* | | | | | | | | | | | | | | | | | | |
| 22017-D | Malt | Beer | 3.83 | 5.06 | 12.72 | 60.22 | .214 | .001 | 1.32 | 2.30 | .603 | .206 | .079 | .63 | ........ | 12 | .712 | .243 | .093 |
| 22018-D | ...do | ...do | 3.90 | 5.06 | 12.86 | 60.65 | .223 | .002 | 1.34 | 2.03 | .606 | .199 | .077 | .88 | ........ | 13 | .701 | .230 | .090 |
| 22020-D | ...do | ...do | 3.69 | 5.12 | 12.50 | 59.04 | .234 | .002 | 1.57 | 2.20 | .630 | .203 | .080 | .52 | ........ | 11 | .756 | .244 | .096 |
| 22021-D | ...do | ...do | 3.63 | 5.54 | 12.80 | 56.72 | .219 | .001 | 1.82 | 2.15 | .626 | .205 | .081 | .74 | ........ | 10 | .734 | .240 | .095 |
| 22042-D | 80 per cent malt and 20 per cent rice. | ...do | 3.16 | 5.13 | 11.45 | 55.20 | .241 | .003 | 1.55 | 2.48 | .395 | .154 | .056 | .55 | +37.2 | 2 | .517 | .202 | .073 |
| | *Brewery No. 3.* | | | | | | | | | | | | | | | | | | |
| 29517-B | 80 per cent malt and 20 per cent cerealin. | Ale | 6.33 | 6.77 | 19.43 | 65.15 | .357 | .005 | 1.42 | 3.26 | .622 | .279 | .066 | .75 | +40.4 | ........ | .480 | .215 | .051 |
| 22027-D | 78 per cent malt and 22 per cent cerealin. | ...do | 5.14 | 5.82 | 16.10 | 63.85 | .205 | .004 | 1.23 | 3.27 | .488 | .189 | .054 | .64 | +41.2 | 3 | .455 | .176 | .050 |
| 22040-D | ...do | ...do | 5.31 | 6.17 | 16.79 | 63.25 | .291 | .004 | 1.40 | 3.29 | .533 | .189 | .050 | .76 | +38.6 | 4 | .476 | .169 | .045 |
| 22048-D | ...do | ...do | 5.33 | 6.15 | 16.81 | 63.42 | .232 | .002 | 1.51 | 3.29 | .563 | .203 | .045 | .58 | +40.4 | 4 | .502 | .181 | .040 |
| 29512-B | 75 per cent malt and 25 per cent cerealin. | ...do | 5.32 | 8.88 | 19.52 | 54.51 | .366 | .008 | 2.62 | 4.28 | .650 | .266 | .057 | 1.06 | +65.2 | 3 | .499 | .204 | .044 |
| 29514-B | ...do | ...do | 5.43 | 8.25 | 19.11 | 56.83 | .357 | .005 | 2.45 | 3.99 | .650 | .250 | .056 | .91 | +59.8 | 2 | .509 | .196 | .044 |
| 29519-B | ...do | ...do | 5.43 | 8.70 | 19.56 | 55.52 | .278 | .006 | 2.56 | 4.21 | .655 | .249 | .056 | 1.02 | +64.0 | 2 | .502 | .191 | .043 |
| 22080-D | 65 per cent malt, 28 per cent cerealin, and 7 per cent brewer's sugar. | ...do | 4.79 | 5.80 | 15.38 | 62.29 | .223 | .003 | 1.14 | 3.20 | .419 | .190 | .038 | .85 | +40.0 | 5 | .409 | .185 | .037 |
| 22039-D | ...do | ...do | 5.10 | 5.55 | 15.75 | 64.64 | .223 | .003 | 1.24 | 2.84 | .465 | .184 | .042 | .37 | +37.6 | 5 | .443 | .175 | .040 |
| 22043-D | ...do | ...do | 4.91 | 5.50 | 15.32 | 63.27 | .214 | .003 | 1.38 | 2.81 | .430 | .170 | .042 | .70 | +38.0 | 4 | .427 | .166 | .041 |

[1] Brewer's scale.

In the results given under brewery No. 1, a beer made entirely from malt is compared with a beer made from 65 per cent of malt and 35 per cent of cerealin, and with a beer made from 60 per cent of malt and 40 per cent of corn, in all of which the same quality of malt was used.

In the case of brewery No. 2, a beer made entirely from malt and a beer made from 80 per cent of malt and 20 per cent of rice are given, in both of which the same quality of malt was used.

Under brewery No. 3 are given determinations for ales prepared from 80 per cent of malt and 20 per cent of cerealin; 78 per cent of malt and 22 per cent of cerealin; 75 per cent of malt and 25 per cent of cerealin; and 65 per cent of malt, 28 per cent of cerealin, and 7 per cent of brewer's sugar. The same quality of malt was used in all of these brews, but the brews were of different strengths.

Table VII is given practically in two parts, the first part showing the actual results obtained by the analysis of the finished beer or ale and the second part showing protein, ash, and phosphoric acid calculated to the basis of a uniform wort containing 15 per cent of solids.

Taking into consideration the actual results obtained upon the beers and ales, it will be seen in the case of brewery No. 1 that the three beers vary in composition to a considerable degree. Especially is this variation marked in regard to the protein, ash, and phosphoric acid contents, which exhibit a marked decrease approximately in direct proportion to the amount of cerealin or corn substituted for malt. The same condition is apparent in the case of the products made in brewery No. 2, the beer made from 80 per cent of malt and 20 per cent of rice showing a material reduction in protein, ash, and phosphoric acid. In brewery No. 3, however, a somewhat different condition is noted. Unfortunately, there is no all-malt product of this brewery to compare with the brews made from a portion of cerealin or from cerealin and brewer's sugar. It will be noted, however, that when the actual results obtained on the finished products of this brewery are compared with those of the all-malt brews of breweries Nos. 1 and 2, they do not clearly show a reduction of protein and ash as might be expected. For example, in the case of one of the samples of the ale made with 25 per cent of cerealin and 75 per cent of malt (sample No. 29512–B), the percentage of protein is 0.65 and of the ash 0.266. The percentages of protein and ash for the three samples of this ale represented by Nos. 29512–B, 29514–B, and 29519–B are higher than were found in any of the all-malt products of the first two breweries under consideration. This, however, can be readily explained when it is considered that in the case of brewery No. 2 in the all-malt beers (sample No. 22017–D) only 58 pounds of malt were used in the preparation of a barrel of beer containing 31 gallons; while in the case of sample No. 29512–B there were used, in preparing a barrel of similar capacity, 68 pounds of malt and 23 pounds of cerealin. That is, in the second product there is, in the same volume of liquid, the extractive material from 68 pounds of malt and 23 pounds of cerealin, while in the first product there is present the extractive material from only 58 pounds of malt. Since the analysis is made upon the finished liquid it is evident that the percentage composition of any particular ingredient should be very much larger in the second product because of the very much larger amount of material used in its preparation. It is apparent, therefore, that no direct comparison can be made between the percentage composition of these different brews in order to determine the effects of the raw materials upon their composition.

The most satisfactory way to have tested this question of the effect of raw materials on the finished product would have been to make a series of worts with exactly the same percentage of solids, some of pure malt and others of mixtures of pure malt and corn, rice, and cerealin; then a direct comparison between the results would have shown the effects of these various materials. This method was impracticable because it was necessary to take the brews as actually made under varying commercial conditions. The object sought can be accomplished, however, by calculating the results of these analyses either to the basis of dry material in the original wort or by calculating them to the basis of a wort with constant water content. It was decided to calculate all of the results to the basis of a wort containing 15 per cent of solids, as this would give a uniform basis for comparison and would be approximately an average wort. The method employed in calculating the various beers and ales to this uniform basis was as follows:

The percentage of solids in the original wort was calculated by multiplying the percentage by weight of alcohol by 2 and adding the percentage by weight of extract. The result for an ordinary beer would be about 12 per cent, while in the case of a very heavy ale it might be as high as 18 or 20 per cent. The actual percentages of protein, ash, and phosphoric acid found by analysis were then calculated to the basis of a uniform wort containing 15 per cent of solids. This was the method used for preparing the second part of this table. A study of this portion of the table shows the actual effects of the various substitutes used for malt on the composition of the fermented product. For instance, the first of the all-malt beers from brewery No. 2 (22017–D) showed in the analysis of the original product a protein percentage of 0.603, an ash percentage of 0.206, and a phosphoric acid percentage of 0.079. When calculated to the basis of a wort containing 15 per cent of solids instead of 12.72 per cent (the actual percentage of solids in the wort from which it was made), it gave the following percentages: Protein, 0.712; ash, 0.243; and phosphoric acid, 0.093. In the case of brewery No. 3, sample No. 29512–B, where the original analysis of the product showed 0.650 per cent of protein, 0.266 of ash, and 0.057 of phosphoric acid, it will be found that when this product is calculated to the basis of a wort of 15 per cent of solids instead of a wort of 19.52 (the actual percentage of solids in the wort in this case) the percentage of ash is 0.204, of protein 0.499, and of phosphoric acid 0.044. A comparison of these results shows that in the protein, ash, and phosphoric acid there has been a material reduction below the figures found upon the all-malt beer, due to the presence of the 25 per cent of cerealin. A study of these results, calculated to the basis of 15 per cent of solids in the wort, shows very clearly that the general effect of the substitution of cerealin, brewer's sugar, rice, and corn is to reduce the content of ash, protein, and phosphoric acid.

It is evident from the results here given that the most important things to be considered in judging the nature of the raw materials used in the preparation of a beer are the quantities of protein, phosphoric acid, and ash; as the other constituents present in the finished beer are more or less variable, the quantities present depending upon the methods of mashing and fermentation.

Table VIII contains a summary of results giving the ash, protein, and phosphoric acid in all of the finished products of known composition which were examined, calculated to the basis of a uniform wort of 15 per cent of solids.

TABLE VIII.—*Summary of the results of analyses (showing ash, protein, and phosphoric acid determinations) in all finished products of known composition, calculated to the basis of a uniform wort containing 15 per cent of solids.*

| Raw materials. | Products. | Ash. | Protein (N×6.25). | Phosphoric acid (as $P_2O_5$). |
|---|---|---|---|---|
| Malt | Beers: 21 samples: | *Per cent.* | *Per cent.* | *Per cent.* |
| | Maximum | 0.336 | 1.079 | 0.143 |
| | Minimum | .230 | .701 | .087 |
| | Average | .275 | .870 | .109 |
| 80 per cent malt and 20 per cent rice | Beer | .202 | .517 | .073 |
| 66 per cent malt and 34 per cent rice | do | .198 | .555 | .084 |
| 62 per cent malt and 38 per cent rice | do | .205 | .488 | .061 |
| 55 per cent malt and 45 per cent rice | do | .148 | .380 | .077 |
| 50 per cent malt and 50 per cent rice | do | .167 | .351 | .056 |
| | Maximum | .205 | .555 | .084 |
| 70 per cent malt and 30 per cent corn | Beer | .199 | .343 | .057 |
| Do | do | .188 | .367 | .065 |
| 68 per cent malt and 32 per cent corn | do | .150 | .461 | .057 |
| Do | do | .181 | .466 | .062 |
| Do | do | .164 | .459 | .056 |
| 60 per cent malt and 40 per cent corn | do | .215 | .563 | .074 |
| Do | do | .188 | .593 | .076 |
| Do | do | .223 | .597 | .074 |
| 45 per cent malt and 55 per cent corn | do | .145 | .347 | .057 |
| | Maximum | .223 | .597 | .076 |
| 65 per cent malt and 35 per cent cerealin | Beer | .192 | .483 | .057 |
| 80 per cent malt and 20 per cent cerealin | Ale | .215 | .480 | .051 |
| 78 per cent malt and 22 per cent cerealin | do | .176 | .455 | .050 |
| Do | do | .169 | .476 | .045 |
| Do | do | .181 | .502 | .040 |
| 75 per cent malt and 25 per cent cerealin | do | .204 | .499 | .044 |
| Do | do | .196 | .509 | .044 |
| Do | do | .191 | .502 | .043 |
| 65 per cent malt, 7 per cent brewer's sugar, and 28 per cent cerealin | do | .185 | .409 | .037 |
| Do | do | .175 | .443 | .040 |
| Do | do | .166 | .427 | .041 |
| | Maximum | .213 | .509 | .051 |

A study of the results given in Table VIII shows that in the case of American beers the all-malt beers are higher in ash, protein, and phosphoric acid than are any of the beers made from a mixed mash of malt and other cereals. The difference is sufficiently marked to make it possible to draw a rather sharp line between the all-malt beers and the beers made from the present commercial mixtures. Take, for instance, the beers made from mixtures of malt and rice in which the proportion of rice varies from 20 to 50 per cent. It will be seen that in none of these samples is the ash, phosphoric acid, or protein so high as the minimum found in the all-malt beers. The same will be seen in the case of the malt-and-corn beers. In none of the malt-and-corn beers is the ash, protein, or phosphoric acid so high as the minimum found in the all-malt beers, and the same is true of the mixtures of malt and cerealin and of malt, brewer's sugar, and cerealin. This shows clearly that the commercial beers made in this country from malt and malt substitutes can be distinguished readily from all-malt beers.

When the average composition of the 21 all-malt beers examined is taken into consideration it will be seen that there is a very sharp line of demarcation between the all-malt and the malt, rice, and corn products. From the figures which were obtained upon American beers it would seem that protein as a rule is more sharply reduced by the addition of malt substitutes than is the ash or the phosphoric acid, although where corn or cerealin is used there is a very marked reduction in the amount of phosphoric acid. It would appear, therefore, from the results of this investigation that in the consideration of American beers it will be comparatively easy to draw a line between beers made solely from malt and those made from mixtures of malt with rice, corn, and other substitutes.

This conclusion is not entirely in agreement with the results which have been obtained by others upon foreign beers, in the preparation of which low protein barleys have been used. Joseph Race[1] has reported some interesting results of an investigation carried on for the same purpose as that for which this particular investigation was undertaken; that is, to distinguish between all-malt beers and those made from substitutes. His results do not show as sharp a reduction of the protein, but he found in his all-malt beers a very much lower percentage of total protein than was found in the malt beers of this country. He did observe, however, a material reduction of the phosphoric acid due to the use of substitutes. Unfortunately, he made his determination of phosphoric acid in the ash, and while he reports a marked difference between the phosphoric acid content of the malt beers and those made from substitutes, his total figures for phosphoric acid are much lower than those reported in this bulletin. For this reason the figures for total phosphoric acid given by him are not at all comparable with those determined by the moist combustion method, by the uranium acetate method, or by the method of ashing with calcium acetate.[1]

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[1] J. Soc. Chem. Ind., 27 (1908), 544-547.

The same fact observed by Race, namely, that foreign beers are of low protein content, is shown very clearly in the published literature on European beers in general. König[2] gives the following results of analyses made by himself and H. Weigmann of two all-malt beers, calculated to the basis of a wort containing 15 per cent of solids:

| Beer and percentage of wort. | Protein. | Ash. | Phosphoric acid. |
|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* |
| Pure malt beer: | | | |
| 12 per cent wort | 0.548 | 0.259 | 0.098 |
| 14 per cent wort | .457 | .214 | .076 |

From these results of König it will be seen that the protein content of these beers is considerably less than that of the beers examined by the writers. As the phosphoric acid and ash results, however, are practically the same as in American beers, it might be expected that the use of substitutes in place of the low-protein malt would not show so sharp a reduction of the protein as was found by the authors, although one would expect a reduction in phosphoric acid and ash similar to that found in American beers. This is confirmed by the results obtained by Race.

Robert Wahl[3] made parallel brewings of a high-protein barley and a low-protein barley, and from these obtained two beers which, when calculated to a uniform wort with 15 per cent of solids, showed a total protein in the beer made from the low-protein malt of 0.734 per cent, and in the beer made from the high-protein malt 1.041 per cent. This clearly indicates that where a beer is made from high-protein barley, as is the case with practically all of the beers made in this country,[4] the reduction in protein by the use of substitutes will be a valuable index to the true nature of the product. This, when taken in connection with the reduction of phosphoric acid brought about by the use of substitutes, gives two factors of value in judging American beers, to determine whether or not substitutes have been used; while in the case of beers made from low-protein barley there is practically only one factor, namely, the reduction of phosphoric acid.

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[1] Riley, in his report to the Association of Official Agricultural Chemists for the year 1913, showed that a large proportion of the phosphoric acid was ordinarily lost when the beer was directly ashed (J. Assoc. Off. Agr. Chemists, 1 (1915), 138–143). For this reason, in comparing the amount of phosphoric acid given in the literature on beers, it is very essential to know the method used for determining the phosphoric acid.

[2] König, F. J., Chemie der Menschlichen Nahrungs- und Genussmittel, 4th ed., v. 1, p. 1154. Berlin, 1903.

[3] Am. Brewers' Rev., 18 (1904), 339.

[4] Wahl, Robert. *In* Am. Brewers' Rev., 29 (1915), 316–317.

After this rather extensive study had been made at the three breweries, the investigation was extended to include breweries in various sections of the country where different types of raw materials were used. A special effort was made to obtain authentic samples of practically all of the malt beers made in this country and also a large series of malt-and-rice and malt-and-corn beers. In Table IX have been tabulated the results obtained on all-malt beers. All of these results show practically the same condition noted in the other samples of malt beer; that is, a comparatively high protein and phosphoric acid content as compared with beers made in part from rice or corn. These malt beers show figures considerably higher in protein than those given in the literature for all-malt beers made from the low-protein malt of Europe.

TABLE IX.—*Analyses of all-malt American beers.*

| Sample No. | Alcohol. | Extract (Schultz and Ostermann). | Extract in original wort (calculated). | Degree of fermentation. | Total acid as lactic. | Volatile acid as acetic. | Reducing sugars as anhydrous maltose. | Dextrin. | Protein (N×6.25). | Ash. | Phosphoric acid (as $P_2O_5$). | Undetermined. | Polarimeter. | Color (Lovibond) in ½ inch cell. | Calculated to basis of wort with 15 per cent of solids. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Protein (N×6.25). | Ash. | Phosphoric acid (as $P_2O_5$). |
| | *Per cent by weight.* | *Per cent.* | *Per cent.* | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Degrees V.* | *Degrees.*[1] | *Per cent.* | *Per cent.* | *Per cent.* |
| 22017-D... | 3.83 | 5.06 | 12.72 | 60.22 | 0.214 | 0.001 | 1.32 | 2.30 | 0.603 | 0.206 | 0.079 | 0.63 | .......... | 12 | 0.712 | 0.243 | 0.093 |
| 22018-D... | 3.90 | 5.06 | 12.86 | 60.65 | .223 | .002 | 1.34 | 2.03 | .606 | .199 | .077 | .88 | .......... | 13 | .701 | .230 | .090 |
| 22020-D... | 3.69 | 5.12 | 12.50 | 59.04 | .234 | .002 | 1.57 | 2.20 | .630 | .203 | .080 | .52 | .......... | 11 | .756 | .244 | .096 |
| 22021-D... | 3.63 | 5.54 | 12.80 | 56.72 | .219 | .001 | 1.82 | 2.15 | .626 | .205 | .081 | .74 | .......... | 10 | .734 | .240 | .095 |
| 16289-C.... | 3.00 | 5.88 | 11.88 | 50.50 | .228 | .003 | 1.33 | 2.68 | .752 | .242 | .081 | .88 | +36.8 | .......... | .950 | .306 | .102 |
| 16299-C.... | 2.84 | 6.02 | 11.70 | 48.55 | .232 | .012 | 1.38 | 2.77 | .724 | .237 | .088 | .91 | +40.0 | .......... | .932 | .304 | .113 |
| 20714-D... | 3.07 | 5.80 | 11.94 | 51.42 | .241 | .012 | 1.45 | 2.64 | .721 | .225 | .089 | .76 | +36.4 | 3 | .906 | .283 | .112 |
| 20715-D... | 2.95 | 5.77 | 11.67 | 50.56 | .228 | .009 | 1.43 | 2.67 | .725 | .213 | .088 | .73 | +36.0 | 4 | .932 | .274 | .113 |
| 28571-E.... | 3.68 | 4.44 | 11.80 | 62.45 | .232 | .010 | 1.06 | 1.67 | .653 | .229 | .096 | .83 | +21.6 | .......... | .830 | .291 | .122 |
| 23585-E.... | 3.60 | 5.04 | 12.24 | 58.82 | .277 | .005 | 1.36 | 1.81 | .811 | .257 | .102 | .80 | +23.2 | 6 | .994 | .315 | .124 |
| 23528-E.... | 3.28 | 6.36 | 12.92 | 50.80 | .384 | .016 | 1.62 | 2.74 | .905 | .239 | .123 | .86 | +37.2 | 13 | 1.051 | .277 | .143 |
| 23533-E.... | 3.41 | 5.48 | 12.30 | 55.45 | .232 | .008 | 1.48 | 2.44 | .612 | .200 | .086 | .75 | +33.6 | 3 | .747 | .244 | .105 |
| 23537-E.... | 3.80 | 7.26 | 14.86 | 51.35 | .250 | .012 | 2.51 | 2.95 | .802 | .228 | .098 | .77 | +44.0 | 14 | .809 | .230 | .099 |
| 23588-E.... | 3.16 | 6.11 | 12.43 | 50.84 | .250 | .008 | 1.93 | 2.41 | .797 | .208 | .086 | .76 | +37.2 | 4 | .952 | .251 | .104 |
| 23538-E.... | 3.13 | 6.61 | 12.77 | 48.24 | .250 | .009 | 2.13 | 2.82 | .612 | .225 | .087 | .82 | +43.6 | 9 | .719 | .264 | .102 |
| 23589-E.... | 3.35 | 6.21 | 12.91 | 51.90 | .178 | .017 | 1.78 | 2.87 | .627 | .204 | .075 | .73 | +40.0 | 7 | .729 | .237 | .087 |
| 23539-E.... | 3.22 | 6.63 | 13.27 | 48.53 | .312 | .017 | 2.18 | 2.58 | .778 | .248 | .097 | .84 | +38.8 | 22 | .879 | .280 | .109 |
| 23540-E.... | 3.93 | 6.77 | 14.63 | 53.73 | .348 | .007 | 2.64 | 1.87 | 1.010 | .324 | .129 | .93 | +34.0 | 18 | 1.035 | .332 | .132 |
| 23590-E.... | 3.48 | 5.45 | 12.41 | 56.09 | .375 | .010 | 2.21 | 1.48 | .892 | .264 | .109 | .60 | +25.6 | 7 | 1.079 | .319 | .132 |
| 23541-E.... | 3.12 | 5.06 | 11.30 | 55.22 | .259 | .004 | 1.69 | 1.27 | .777 | .253 | .087 | 1.07 | +20.0 | 4 | 1.031 | .336 | .115 |
| 14004-H... | 3.07 | 5.55 | 11.69 | 52.54 | .223 | .013 | 1.59 | 2.64 | .615 | .207 | .072 | .49 | .......... | 5 | .789 | .266 | .092 |

[1] Brewer's scale.

In Tables X and XI are given the results for beers made from malt and rice and from malt and corn. A study of these tables shows the same condition as was noted in the other tables giving malt-and-rice and malt-and-corn beers; that is, the beers have a lower protein and phosphoric acid content than those made entirely from malt.

TABLE X.—*Analyses of malt-and-rice American beers.*

| Sample No. | Raw materials. | Alcohol. | Extract (Schultz and Ostermann). | Extract in original wort (calculated). | Degree of fermentation. | Total acid as lactic. | Volatile acid as acetic. | Reducing sugars as anhydrous maltose. | Dextrin. |
|---|---|---|---|---|---|---|---|---|---|
| | | *Per ct. by weight.* | *Per ct.* | *Per ct.* | | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* |
| 22042-D | 80 per cent malt and 20 per cent rice | 3.16 | 5.13 | 11.45 | 55.20 | 0.241 | 0.003 | 1.55 | 2.41 |
| 23527-E | 66 per cent malt and 34 per cent rice | 3.32 | 5.50 | 12.14 | 54.70 | .196 | .008 | 1.46 | 2.74 |
| 23581-E | 62 per cent malt and 38 per cent rice | 2.86 | 6.16 | 11.88 | 48.16 | .178 | .014 | 1.77 | 3.15 |
| 23587-E | 55 per cent malt and 45 per cent rice | 3.56 | 4.96 | 12.08 | 58.94 | .151 | .007 | 1.24 | 2.53 |
| 23586-E | 50 per cent malt and 50 per cent rice | 3.44 | 5.67 | 12.55 | 54.82 | .160 | .008 | 1.44 | 3.08 |

| Sample No. | Raw materials. | Protein (N× 6.25). | Ash. | Phosphoric acid (as $P_2O_5$). | Undetermined. | Polarimeter. | Color (Lovibond) in ½-inch cell. | Calculated to basis of wort with 15 per cent of solids. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Protein (N× 6.25). | Ash. | Phosphoric acid (as $P_2O_5$). |
| | | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Degrees V.* | *Degrees.*[1] | *Per ct.* | *Per ct.* | *Per ct.* |
| 22042-D | 80 per cent malt and 20 per cent rice | 0.395 | 0.154 | 0.056 | 0.62 | +37.2 | 2 | 0.517 | 0.202 | 0.073 |
| 23527-E | 66 per cent malt and 34 per cent rice | .449 | .160 | .068 | .69 | +40.0 | 2 | .555 | .198 | .084 |
| 23581-E | 62 per cent malt and 38 per cent rice | .386 | .162 | .048 | .69 | +48.6 | ....... | .488 | .205 | .061 |
| 23587-E | 55 per cent malt and 45 per cent rice | .306 | .119 | .062 | .76 | +37.0 | 2 | .380 | .148 | .077 |
| 23586-E | 50 per cent malt and 50 per cent rice | .294 | .140 | .047 | .72 | +46.4 | 2 | .351 | .167 | .056 |

[1] Brewer's scale.

TABLE XI.—*Analyses of malt-and-corn American beers.*

| Sample No. | Raw materials. | Alcohol. | Extract (Schultz and Ostermann). | Extract in original wort (calculated). | Degree of fermentation. | Total acid as lactic. | Volatile acid as acetic. | Reducing sugars as anhydrous maltose. | Dextrin. |
|---|---|---|---|---|---|---|---|---|---|
| | | *Per ct. by weight.* | *Per ct.* | *Per ct.* | | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* |
| 3534-E | 70 per cent malt and 30 per cent corn | 2.75 | 5.53 | 11.03 | 50.32 | 0.125 | 0.005 | 1.27 | 3.13 |
| 23535-E | .....do | 3.03 | 4.85 | 10.91 | 55.55 | .224 | .011 | 1.15 | 2.76 |
| 23518-E | 68 per cent malt and 32 per cent corn | 3.37 | 5.96 | 12.70 | 53.07 | .116 | .006 | 1.63 | 3.07 |
| 23561-E | .....do | 3.26 | 6.14 | 12.66 | 51.50 | .134 | .016 | 1.54 | 3.07 |
| 23572-E | .....do | 3.37 | 6.07 | 12.81 | 52.62 | .143 | .020 | 1.56 | 3.29 |
| 23584-E | 60 per cent malt and 40 per cent corn | 3.09 | 4.90 | 11.08 | 55.78 | .178 | .020 | 1.35 | 2.43 |
| 23523-E | .....do | 3.16 | 6.07 | 12.39 | 51.01 | .214 | .009 | 1.60 | 3.36 |
| 23660-E | .....do | 3.26 | 6.07 | 12.59 | 51.79 | .205 | .009 | 1.55 | 3.06 |
| 16286-C | .....do | 3.19 | 5.60 | 11.98 | 53.34 | .173 | .014 | 1.85 | 2.61 |
| 16287-C | .....do | 3.23 | 5.67 | 12.13 | 53.26 | .178 | .014 | 1.84 | 2.41 |
| 23524-E | 45 per cent malt and 55 per cent corn | 3.43 | 5.75 | 12.61 | 54.40 | .169 | .007 | 1.44 | 3.19 |

| Sample No. | Raw materials. | Protein (N × 6.25). | Ash. | Phosphoric acid (as $P_2O_5$). | Undetermined. | Polarimeter. | Color (Lovibond) in ½-inch cell. | Calculated to basis of wort with 15 per cent of solids. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Protein (N × 6.25). | Ash. | Phosphoric acid (as $P_2O_5$). |
| | | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Degrees V.* | *Degrees.*[1] | *Per ct.* | *Per ct.* | *Per ct.* |
| 23534-E | 70 per cent malt and 30 per cent corn | 0.252 | 0.146 | 0.042 | 0.73 | +42.6 | 2 | 0.343 | 0.199 | 0.057 |
| 23535-E | .....do | .267 | .137 | .047 | .53 | +37.2 | 2 | .367 | .188 | .065 |
| 23518-E | 68 per cent malt and 32 per cent corn | .390 | .127 | .048 | .74 | +49.6 | 3 | .461 | .150 | .057 |
| 23561-E | .....do | .393 | .153 | .052 | .98 | +48.0 | ....... | .466 | .181 | .062 |
| 23572-E | .....do | .392 | .140 | .048 | .69 | +47.0 | ....... | .459 | .164 | .056 |
| 23584-E | 60 per cent malt and 40 per cent corn | .416 | .159 | .055 | .54 | +34.6 | ....... | .563 | .215 | .074 |
| 23523-E | .....do | .490 | .155 | .064 | .46 | +45.0 | 5 | .593 | .188 | .076 |
| 23660-E | .....do | .501 | .187 | .062 | .77 | +44.4 | 5 | .597 | .223 | .074 |
| 16286-C | .....do | .311 | .219 | .057 | .61 | +41.0 | ....... | .389 | .274 | .071 |
| 16287-C | .....do | .322 | .205 | .055 | .89 | +41.0 | ....... | .398 | .254 | .068 |
| 23524-E | 45 per cent malt and 55 per cent corn | .292 | .122 | .048 | .71 | +45.6 | 2 | .347 | .145 | .057 |

[1] Brewer's scale.

In Table XII have been brought together the results of the examination of a large number of commercial beers of American production, which were represented to be made from malt and hops. This representation subsequently proved to be false, although exact information as to the amount or kind of substitute used is not available. These results are of value, however, in showing the general composition of American beers made from the ordinary commercial mixtures and clearly indicate that by taking into consideration the ash, protein, and phosphoric acid content it is practicable to distinguish commercial beers made in this country from malt and malt substitutes from beers made from malt alone.

TABLE XII.—*Analyses of American beers incorrectly represented to be all-malt.*

| Sample No. | Alcohol. | Extract (Schultz and Ostermann). | Extract in original wort (calculated). | Degree of fermentation. | Total acid as lactic. | Volatile acid as acetic. | Reducing sugars as anhydrous maltose. | Dextrin. | Protein (N× 6.25). | Ash. | Phosphoric acid (as $P_2O_5$). | Undetermined. | Polarimeter. | Color (Lovibond) in ½-inch cell. | Calculated to basis of wort with 15 per cent of solids. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Protein (N× 6.25). | Ash. | Phosphoric acid (as $P_2O_5$). |
| | *Per cent by weight.* | *Per cent.* | *Per cent.* | | *Per ct.* | *Per cent.* | *Per cent.* | *Per ct.* | *Per cent.* | *Per ct.* | *Per cent.* | *Per cent.* | *Degrees V.* | *Degrees.*[1] | *Per cent.* | *Per ct.* | *Per cent.* |
| 2417-E | 3.67 | 4.66 | 12.00 | 61.33 | 0.154 | 0.013 | 1.59 | 1.97 | 0.341 | 0.120 | 0.053 | 0.64 | +31.0 | 1 | 0.426 | 0.150 | 0.066 |
| 36612-E | 3.10 | 7.55 | 13.75 | 45.09 | .232 | .017 | 2.33 | 3.93 | .274 | .149 | .043 | .87 | +54.4 | 35 | .299 | .163 | .047 |
| 1146-E | 4.23 | 7.35 | 15.81 | 53.51 | .241 | .029 | 2.21 | 3.39 | .472 | .202 | .074 | 1.08 | +50.0 | 32 | .448 | .192 | .070 |
| 3014-E | 3.26 | 6.74 | 13.26 | 49.17 | .167 | .014 | 2.74 | 2.56 | .406 | .147 | .060 | .89 | +49.6 | 3 | .459 | .166 | .068 |
| 2538-E | 2.86 | 6.69 | 12.41 | 46.09 | .214 | .017 | 3.22 | 2.12 | .390 | .181 | .050 | .78 | +43.2 | 54 | .472 | .219 | .060 |
| 1734-E | 3.55 | 6.55 | 13.65 | 52.02 | .250 | .028 | 1.87 | 3.58 | .303 | .145 | .048 | .65 | +53.0 | 3 | .333 | .159 | .053 |
| 1154-E | 3.55 | 5.62 | 12.72 | 55.82 | .187 | .014 | 1.88 | 2.52 | .352 | .158 | .043 | .71 | +41.0 | 3 | .415 | .186 | .051 |
| 1006-E | 3.58 | 4.74 | 11.90 | 60.17 | .138 | .017 | 1.42 | 1.99 | .420 | .158 | .057 | .75 | +31.2 | 12 | .529 | .199 | .072 |
| 195-E | 3.56 | 4.21 | 11.33 | 62.84 | .127 | .008 | 2.72 | .77 | .254 | .127 | .044 | .34 | +22.6 | 3 | .336 | .168 | .058 |
| 5022-E | 2.95 | 5.60 | 11.50 | 51.30 | .133 | .022 | 2.30 | 2.20 | .233 | .121 | .036 | .75 | +41.0 | 3 | .304 | .158 | .047 |
| 1005-E | 2.69 | 5.33 | 10.71 | 50.24 | .102 | .010 | 1.77 | 2.34 | .354 | .132 | .048 | .74 | +39.6 | 3 | .496 | .185 | .067 |
| 194-E | 3.18 | 4.00 | 10.36 | 61.39 | .062 | .017 | 1.37 | 1.58 | .296 | .110 | .045 | .64 | +27.0 | 5 | .423 | .159 | .065 |
| 185-E | 3.44 | 3.92 | 10.80 | 63.70 | .141 | .011 | 2.06 | .97 | .250 | .116 | .041 | .52 | +23.2 | 3 | .347 | .161 | .057 |
| 5314-E | 3.78 | 5.65 | 13.21 | 57.15 | .151 | .010 | 1.46 | 2.84 | .416 | .177 | .059 | .76 | +40.8 | 3 | .472 | .201 | .067 |
| 4451-E | 3.23 | 6.52 | 12.98 | 49.77 | .228 | .009 | 2.80 | 2.44 | .519 | .153 | .054 | .61 | .......... | 78 | .599 | .177 | .062 |
| 5696-E | 4.19 | 6.44 | 14.82 | 56.55 | .268 | .012 | 2.15 | 3.06 | .309 | .197 | .082 | .72 | +44.0 | 18 | .313 | .199 | .083 |
| 3359-E | 4.96 | 7.43 | 17.35 | 57.18 | .321 | .019 | 1.76 | 3.74 | .509 | .294 | .074 | 1.13 | +48.4 | 44 | .440 | .254 | .064 |
| 3358-E | 3.23 | 5.53 | 11.99 | 53.83 | .121 | .009 | 1.88 | 2.51 | .314 | .175 | .045 | .65 | +41.0 | 3 | .392 | .219 | .056 |
| 481-E | 3.87 | 5.20 | 12.94 | 59.82 | .147 | .014 | 1.32 | 2.47 | .319 | .163 | .054 | .93 | +36.6 | 2 | .370 | .189 | .063 |
| 687-E | 3.24 | 4.71 | 11.19 | 57.91 | .080 | .009 | 1.63 | 2.20 | .284 | .124 | .048 | .47 | +35.6 | 2 | .382 | .167 | .065 |
| 193-E | 3.66 | 5.75 | 13.07 | 56.01 | .148 | .017 | 1.78 | 2.67 | .346 | .153 | .048 | .80 | +42.8 | 3 | .397 | .176 | .055 |
| 5023-E | 3.16 | 5.30 | 11.62 | 54.39 | .128 | .005 | 1.95 | 2.13 | .214 | .126 | .033 | .88 | +40.0 | 2 | .276 | .163 | .043 |
| 5318-E | 3.57 | 5.20 | 12.34 | 57.86 | .220 | .003 | 1.50 | 2.59 | .320 | .147 | .045 | .64 | +41.8 | 3 | .389 | .179 | .055 |
| 6715-E | 3.75 | 7.98 | 15.48 | 48.45 | .174 | .006 | 2.55 | 3.60 | .430 | .186 | .058 | 1.21 | +61.6 | 14 | .417 | .180 | .056 |
| 6716-E | 3.66 | 7.73 | 15.05 | 48.64 | .187 | .009 | 2.37 | 3.84 | .384 | .164 | .055 | .97 | +61.6 | 14 | .383 | .164 | .055 |
| 2388-E | 2.95 | 5.35 | 11.25 | 52.45 | .080 | .012 | 1.64 | 2.32 | .337 | .135 | .042 | .91 | +40.4 | 2 | .449 | .180 | .056 |
| 2352-E | 3.20 | 4.69 | 11.09 | 57.71 | .147 | .011 | 1.99 | 1.76 | .326 | .146 | .037 | .46 | +32.2 | 3 | .441 | .198 | .050 |
| 2770-E | 3.66 | 5.99 | 13.31 | 55.00 | .169 | .019 | 1.82 | 2.56 | .276 | .194 | .050 | 1.14 | +45.2 | 6 | .311 | .219 | .056 |
| 8705-E | 2.91 | 5.62 | 11.44 | 50.96 | .147 | .017 | 1.86 | 2.58 | .366 | .150 | .041 | .66 | +41.0 | .......... | .480 | .197 | .053 |
| 8706-F | 3.48 | 4.93 | 11.89 | 58.54 | .214 | .022 | 1.83 | 1.83 | .470 | .160 | .062 | .64 | +30.4 | .......... | .593 | .202 | .078 |
| 8704-E | 2.76 | 4.98 | 10.50 | 52.57 | .160 | .010 | 1.62 | 2.26 | .390 | .150 | .054 | .56 | +36.4 | .......... | .557 | .214 | .077 |
| 7839-E | 3.51 | 5.38 | 12.40 | 56.61 | .142 | .012 | 1.57 | 2.77 | .290 | .116 | .031 | .63 | +41.2 | .......... | .351 | .140 | .038 |
| 5707-E | 3.35 | 5.82 | 12.52 | 53.51 | .160 | .011 | 2.01 | 2.65 | .352 | .147 | .048 | .66 | +43.0 | .......... | .422 | .176 | .058 |
| 8171-F | 3.50 | 5.99 | 12.99 | 53.85 | .169 | .013 | 1.92 | 2.67 | .271 | .178 | .054 | .95 | +45.2 | .......... | .313 | .205 | .002 |
| 397-E | 3.73 | 6.71 | 14.17 | 52.65 | .160 | .007 | 1.56 | 3.96 | .324 | .151 | .051 | .72 | +55.2 | 2 | .343 | .160 | .054 |

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[1] Brewer's scale.

The data reported in Tables X, XI, and XII give the results of analyses of commercial American beers obtained from various breweries in different parts of the United States as these beers are found on the market at the present time; hence, they are of general value for the purpose of showing the composition of American beers. These data also are of considerable interest when we compare them with data relating to American beers published by the department in 1887.[1] A comparison of these two sets of figures shows that beers made at the present time have a much lower percentage of alcohol and are made from a wort containing a much lower percentage of solids than beers made a generation ago. The average of 28 samples examined and reported in 1887 in the publication cited[1] showed an average alcohol content of 4.63 per cent by weight and solids in the original wort of 14.79 per cent, while the average of 72 beers representing the products now on the market showed an average of 3.52 per cent by weight of alcohol and solids in the original wort of 12.50 per cent. This is a reduction of 1.11 per cent by weight of alcohol and 2.23 per cent of solids in the original wort.

## CONCLUSIONS.

The all-malt beers made in this country contain higher percentages of protein than the all-malt beers made in Europe, owing to the use in this country of a barley high in protein.

The use of rice, corn or corn products, and brewer's sugar as substitutes for malt reduces the content of protein, ash, and phosphoric acid in the finished beer.

This difference, as regards the protein, ash, and phosphoric acid, is a sufficient basis for distinguishing the all-malt beers made in this country from those containing the commercial mixtures of rice, corn, cerealin, and brewer's sugar.

It is necessary to calculate analytical results to the basis of a common wort in order to interpret them properly.

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[1] U. S. Dept. Agr., Div. Chem., Bul. 13, 1887, pt. 3, p. 282.

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# BULLETIN No. 494

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# A HUMIDIFIER FOR LEMON CURING ROOMS.

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## INTRODUCTION.

In the summer of 1914 the writer became interested in some studies having for their object the control of humidity in the curing rooms of one of the lemon packing houses in southern California. These rooms, 20 in number, are about 20 feet long by 20 feet wide and 10 feet high. They are arranged five on each side of two corridors, which are covered by monitor-type ventilators with slatted sides. The rooms are equipped with ventilating doors along the outer bottom side and inner top side, arranged in such a way that they can be opened easily and held in any position desired, or can be closed so as to prevent any appreciable movement of air from the rooms.

The walls of the rooms are made of galvanized steel. A 4-inch space between the walls, on all sides of the room except the bottom, is filled with redwood sawdust. The floors of the rooms are made of 2 by 4 inch wooden stringers laid flatwise on the joists, with half-inch spaces between them. Underneath each room is a small earth cellar, or pit, in which to place heating appliances for use in raising the temperature of the rooms.

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The condition of relative humidity in the curing rooms is determined by the use of a sling psychrometer. Distilled water at the room temperature and clean cloth covers for the wet bulb have been used, and the directions recommended by the United States Weather Bureau for making accurate use of the sling psychrometer have been carefully followed.

Studies were made to determine the humidity of various parts of empty and filled rooms under different conditions of ventilation, in order to establish intelligently a practicable and satisfactory method for making regular humidity observations. Preliminary determinations of the humidity outside the curing rooms and inside under different conditions of ventilation were made before any control measures were attempted. Regular hourly tests of the relative humidity were made with the sling psychrometer in several parts of the room. In addition to these observations a hygrothermograph was placed in each room, in order to keep a continuous record of the conditions of temperature and humidity.

## OBJECT OF THE EXPERIMENTS.

The object of the humidity studies was to determine the effect of various percentages of relative humidity in the curing rooms upon the curing processes of the lemons and to find out, if possible, the condition resulting in the most satisfactory curing, as shown by the color and texture of rind, the amount of shrinkage during storage, the color and condition of the calyx, or button, as it is commonly called, and the commercial quality of the fruits.

## PLAN OF THE WORK.

Owing to the danger of injury to the lemons in the curing rooms and consequent heavy loss to the owners from improper conditions of temperature and humidity, it was decided to study the condition of relative humidity and its control in empty rooms and with small samples of fruit before attempting the control of humidity in rooms filled with lemons.

In the first place, a study was made of the use of ventilation in controlling the condition of humidity in the curing rooms. At the time these studies were begun, in July, 1914, and during the following four or five months, the relative humidity of the atmosphere at the place where these observations were made was normally very low. The humidity of the air in the warmest part of the day, usually about 2 o'clock in the afternoon, sometimes dropped to less than 10 per cent. The coolest part of the day during this same season was usually about sunrise, and at that time the relative humidity was frequently about 90 per cent and often reached 100 per cent. It was decided to attempt to hold the relative humidity of several curing rooms at about the following conditions, viz, 70 per cent, 75 per cent, 80 per cent, 85 per cent, 90 per cent, and 95 per cent.

The rooms were kept tightly closed during the day and opened at night, when the conditions of the outside atmosphere were such as to make ventilation advisable, in order to assist in maintaining the inside condition of humidity at the desired point. Owing to the extreme fluctuation of the conditions of relative humidity in the outside atmosphere during the day and night and from day to day, ventilation alone was found to be impracticable as a means for maintaining a uniform condition of humidity in the curing rooms. It was found that excessive humidity in the rooms could be quickly reduced by opening the ventilators during the day, when the dew point of the outside air was much lower than that of the air inside the rooms. The real difficulty was found to be that of increasing the humidity in the curing rooms when it dropped below the condition desired.

## METHODS TRIED FOR INCREASING THE RELATIVE HUMIDITY.

Several methods were tried for adding to the humidity in the curing rooms. The ground under one of the curing rooms was sprinkled with water. This method proved objectionable from the fact that by its use molds which were injurious to the fruit began to develop. Then a small perforated water pipe was arranged along the sides of one room, near the top, with a valve to regulate the spray of water from the pipes. This method was found to be inadequate. Later, sacks of coarse, heavy cloth were suspended from these pipes and the spray of water was allowed to fall on them. This method was also found to be ineffective.

A commercial humidifier used in tobacco warehouses was tried in one of the rooms. This machine consists in part of a rapidly revolving fan which throws a fine spray of water into the room. For the conditions in the lemon curing room this apparatus was found to be impracticable and was finally discarded. Other somewhat similar machines manufactured for the same purpose were used and found to be of little or no value for this work.

About this time the writer conceived the idea of increasing the humidity of the curing rooms when necessary by the evaporation of water from saturated cloths. Several ways of doing this were tried. The first apparatus consisted of a shallow, galvanized-steel pan, 2 feet wide, 3 feet long, and 6 inches deep. Into this pan was set a series of wooden frames, about 3 feet long and 1 foot high, spaced about 2 inches apart. During several tests they were covered with cotton and other absorptive cloths. The pan was nearly filled with water, and in this condition the water was drawn into the cloths by capillarity almost to the top of the frames. Over the frames was placed a galvanized-steel cover, or hood, open at one end and so arranged at the other end as to inclose a 16-inch electric fan. The current of air from the fan was directed between and over the saturated cloths. In this way the water was evaporated and given off to the air in the room, increasing the relative humidity more efficiently and safely than by any method previously tried. However, it was soon found that the upper part of the cloths soon became dry under the influence of the air current from the fan, and in an hour or so the effectiveness of the apparatus became greatly diminished.

An attempt was then made to find a cloth more absorptive than the kinds first used. Many materials were tried, with the result that it was decided to use Russian crash, a very coarse linen cloth that is used for making towels and for decorative purposes.

With the use of the Russian crash cloths the efficiency of the humidifier was improved, but it was still imperfect under very dry atmospheric conditions. Various expedients were tried to increase still further the evaporation of the water in the pan, such as by the addition of filter paper, sponges, and other quickly absorptive materials.

## THE INVENTION OF THE HUMIDIFIER.

While working on this phase of the problem, the writer constructed a machine with two water pans, an upper and a lower one, with strips of cloth extending through slots in the bottom of the upper pan to the lower pan. It was thought that in this machine it would be possible to control the flow of water from the upper pan to the cloths through the slots by pressing the slots together by means of thumbscrews. This method was found to be impracticable. It was in this work that the idea occurred of raising the sides of the slots several inches, so that they protruded above the water in the top pan. The cloths were drawn up through the raised slots and the edges were allowed to drop into the water to the bottom of the pan.

Under these conditions, the water in the pan was raised on the cloths by capillarity to the top of the raised slots, where it dropped down through the suspended cloths by gravity and capillarity combined. This arrangement proved to be successful in every respect and met the requirements for use in lemon curing rooms very satisfactorily.

It was found that the rate of flow of water from the upper pan through the cloths to the lower pan could be regulated to a nicety by varying the height of the raised slots, thereby changing the length of the cloth through which the water is drawn by capillarity.

Naturally, the higher the raised slot extended above the water, the slower was the passage of water to the lower pan.

In this work it is desirable to keep the cloths saturated during the operation of the machine, but with little or no excess of water dripping into the lower pan. As finally constructed, after many tests to determine the best arrangement, it was found that raising the slots 4 inches above the bottom of the pan keeps the cloths fully saturated under the conditions in which this machine is used. Another method of controlling the flow of water through the cloths is to vary the quantity of water in the upper pan, filling up the pan so that the water nearly reaches the tops of the raised slots in order to increase the rate of the flow or drawing off some of the water in order to retard its flow.

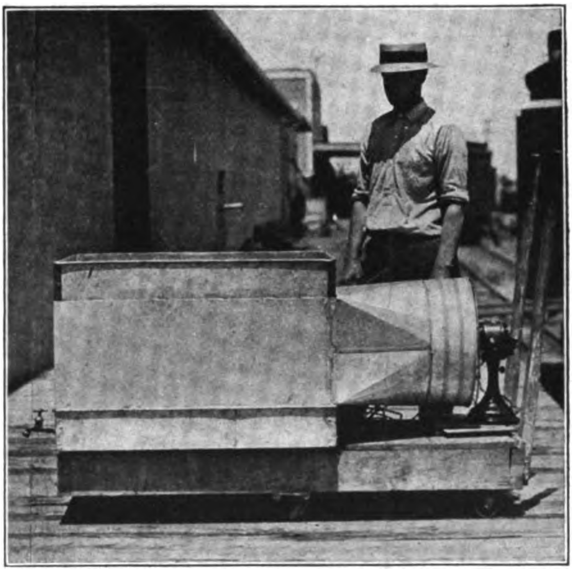

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FIG. 1.—Side view of the humidifier, showing its arrangement on a truck and the spigot for drawing off excessive water in the lower pan.

If it is desirable to stop the absorption of the water by the cloths at any time, this can be done easily by lifting the ends of the cloths out of the water in the upper pan. If the flow of water through the cloths is such as to collect in the lower pan, this excess can be drawn off and returned to the upper pan. Under conditions of very low humidity, when evaporation from the cloths is very rapid, it may be found advisable to maintain some water in the lower pan, as well as in the upper one, in order to keep the cloths fully saturated.

The operation of this humidifier washes all of the air in the room and increases the humidity uniformly, a very important factor in lemon curing rooms. Another fact of great importance is that under conditions of low humidity the humidifier acts rapidly, while under conditions of high humidity it works slowly. One advantage of this condition is that it reduces the danger of raising the humidity of the curing room to a point which would be unfavorable for lemon curing. On an average the humidifier will raise the humidity in the rooms described about 10 per cent per hour in the range from 70 to 90 per cent of relative humidity. In a condition below 50 per cent of relative humidity the humidifier acts more quickly, while at about 90 per cent it works very slowly; in fact, it has been impossible in these experiments to raise the humidity in the curing rooms during very dry days much above 95 per cent with this apparatus.

## CONSTRUCTION OF THE HUMIDIFIER.

The illustrations of the humidifier (figs. 1 and 2) show its general arrangement and its position on a truck, whereby it can be moved from place to place when needed. The detailed structure of the humidifier is shown in figures 3, 4, 5, 6, and 7. The upper pan (1) is 36 inches long, 24 inches wide, and 6 inches deep. The lower pan (2) is of the same dimensions. The side (4) of the cloth chamber (3), which is open at both ends, is 36 inches long and 20 inches high, connecting the upper and lower pans. The raised slots (5) are 4 inches high and extend to within half an inch of either end of the upper pan, so that they are held firmly in position. The upper ends of the raised slots are spread slightly, so as to allow the easy passage of the strips of cloth (6). The pans, sides, and other metal parts are made of galvanized steel of medium weight. The corners of the cloth chamber are strengthened with angle iron. The upper edges of the strips of Russian crash are drawn through the raised slots and allowed to drop down into the water in the upper pan, as shown in figure 7 at 7. The bottom edges of the cloths are bound with strips of sheet metal (8), so as to hold them in place. These bound edges of the cloth strips are held in the lower pan by means of spring clips or clamps (9) which are soldered to the bottom of the lower pan. The strips of cloth are 35 inches wide, so as to fit the raised slots,

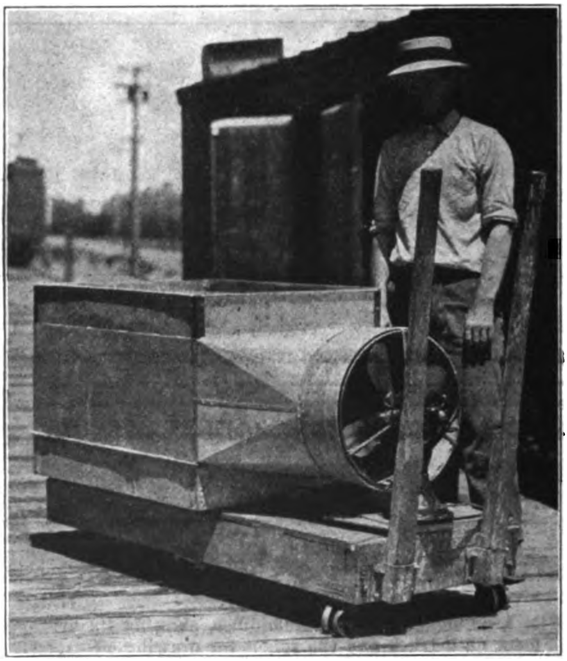

FIG. 2.—Rear view of the humidifier, showing the arrangement of the electric fan in the hood.

and 36 inches long, so as to extend from the lower pan through the raised slots and drop over into the water in the upper pan.

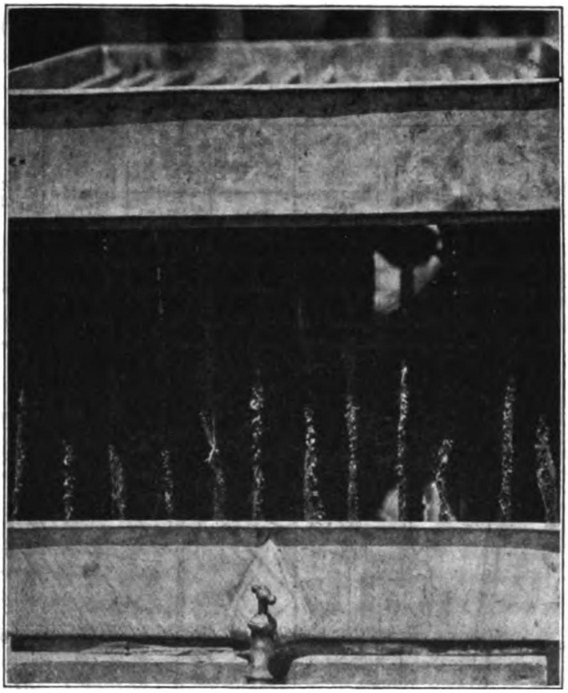

Fig. 3.—Front view of the humidifier, showing the arrangement of the absorptive cloths in the cloth chamber.

In machines constructed after the accompanying illustrations were prepared it was found desirable to have the forward edges of the hood (10) fit inside the opening made by the top and bottom pans and the inner edge of the angle iron in the corners of the cloth chamber. The hood is drawn out to a circle so as to fit the circumference of the blades of the electric fan (11), which is 16 inches in diameter. The humidifier is placed on a truck (12), supported on wheels (13) so arranged that it can be easily moved in any direction by means of the handle (14). Supports (15) are placed under the humidifier and fan to raise them sufficiently to permit a pail to be easily placed and removed from under the spigot (16).

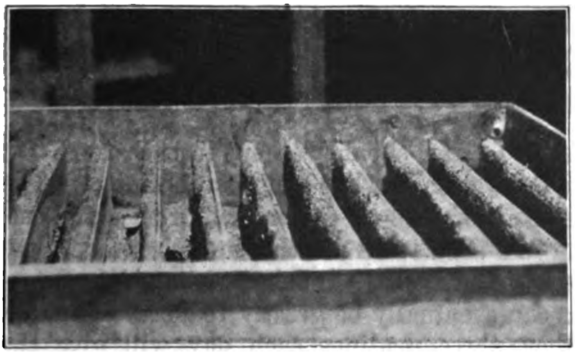

Fig. 4.—Top view of the upper pan, showing the arrangement of the raised slots and the absorptive cloths. The cloths drop from the raised slots to the bottom of the pan.

## OPERATION OF THE HUMIDIFIER.

Space must be left in the curing rooms so that the humidifier can be quickly placed in position for use and easily taken out.

The upper pan should be filled to the proper point with water, care being taken to see that the edges of the cloths are entirely submerged. The fan should then be started.

Frequent readings of the humidity in the rooms should be made, once every hour in the beginning, by means of the sling psychrometer. A record should be kept of these readings from the beginning to the end of the curing process. A convenient form for recording these data is as follows:

*Humidity record of the curing room.*

| Date. | Time. | Air temperature. | Psychrometer readings. |  | Relative humidity. | Dew point. | Outside air. |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Dry bulb. | Wet bulb. |  |  | Temperature. | Humidity. | Dew point. |
| .......... | .......... | .......... | .......... | .......... | .......... | .......... | .......... | .......... | .......... |
| .......... | .......... | .......... | .......... | .......... | .......... | .......... | .......... | .......... | .......... |

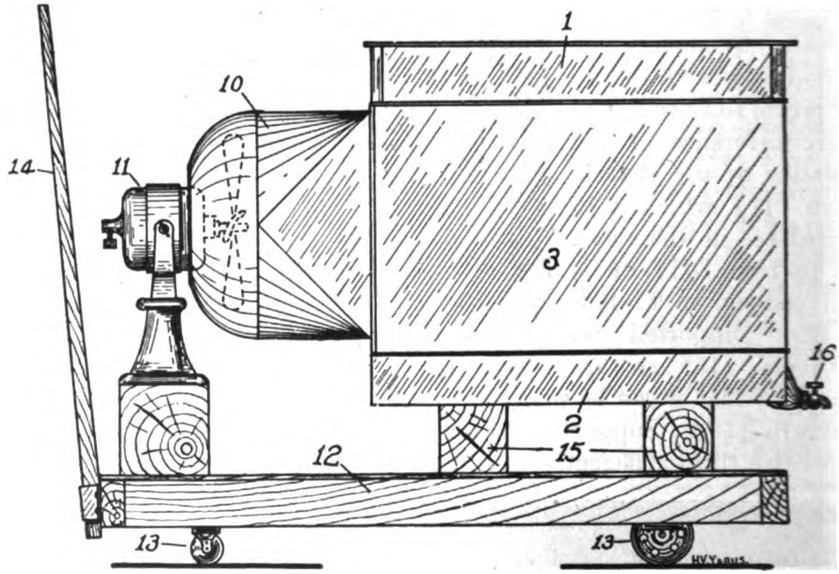

FIG. 5.—Side view of the humidifier, showing details of construction.

A covered jar of distilled water should be kept in each room for moistening the cloth on the wet bulb of the sling psychrometer. The air temperature of the rooms should be determined from standardized thermometers hung in a permanent position in each room.

In practice it has been found that the number of humidity determinations in the rooms can eventually be greatly reduced. Usually, during ordinary weather, three readings each day will give the necessary information for use in handling the humidifier. With fluctuating weather conditions the readings will of necessity be made more often. It is very desirable to make at least one, preferably more than one, daily determination of the air conditions outside the curing rooms, in order to handle the humidifier and the ventilation of the curing rooms intelligently.

For rooms of the kind and size and under the conditions described in this paper one humidifier will generally be sufficient for use in five rooms. With better insulation for the rooms fewer humidifiers will be needed, and where the insulation is not so good or where temperature fluctuations are greater than those where these rooms are located, more humidifiers will be needed. The cost of the humidifier need not exceed $25, in addition to the electric fan. The cost of operation will depend on the cost of running the fan. The depreciation in the value of the apparatus is insignificant.

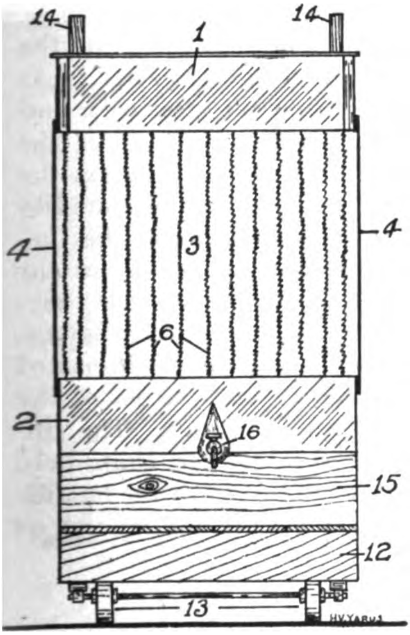

Fig. 6.—End view of the humidifier.

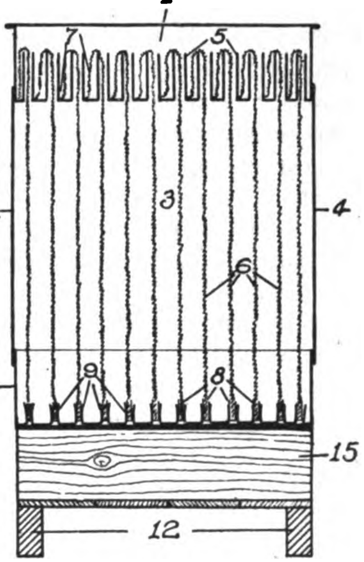

Fig. 7.—Cross section of the humidifier.

If impure water is used in the humidifier it will be found necessary to wash the absorptive cloths occasionally. When the humidifiers are not in use the cloths should be allowed to dry out thoroughly.

## OTHER USES OF THE HUMIDIFIER.

The successful use of the humidifier described in this paper in mproving the humidity of private homes and other living rooms as been demonstrated. In this case, much smaller humidifiers can e used. The noise caused by the vibrations of the electric fan in ontact with the humidifier hood can be largely eliminated by nserting a strip of rubber at this point.

The use of the humidifier in dry or desert sections, in restaurants, ffices, and living rooms not only increases the humidity in these ooms but also lowers their temperature, both of which conditions are very desirable during excessively hot weather. In view of the fact that the only attention needed other than that given the ordinary electric fan is to keep the upper pan filled with water, the operation of this humidifier is simple and practicable.

## RESULTS.

The use of the humidifier described in this bulletin in lemon curing rooms for two seasons has demonstrated the possibility of maintaining a uniform condition of relative humidity in such rooms. The action of the humidifier is entirely safe, and there has been no injury to the fruit in the curing rooms in which it has been used.

The maintenance of a uniform condition of humidity in the curing rooms has resulted in an improved curing of the fruits, as shown by the better color and texture of the rind, the green color and firm condition of the calyx, or "button," and the juiciness of the lemons, as compared with lemons cured in the ordinary way in the same building and at the same time. The best condition of humidity for the curing of lemons, as shown by these experiments, lies between 80 and 90 per cent. While the necessity for the use of the humidifier in curing rooms varies in accordance with the characteristic atmospheric conditions of different lemon-growing regions, it can be said safely that in order to maintain uniform conditions of humidity the use of humidifiers is advisable at some seasons of the year in all the lemon districts of southern California. The improved appearance and quality of one carload of the fruits held under uniform conditions of humidity through the use of the humidifier are likely to more than pay for the humidifier and its cost of operation for the entire year.

## SUMMARY.

A humidifier for use in maintaining conditions of uniform humidity in lemon curing rooms was invented by the writer in 1914.

This humidifier was the outcome of a series of experiments for the purpose of controlling the conditions of humidity in lemon curing rooms.

It has been satisfactorily and successfully used for two seasons for the purpose for which it was built, and also for improving the air conditions in living rooms in private houses and elsewhere in California.

The arrangement and structure of the humidifier are described and illustrated in this paper. It need not cost, aside from the electric fan, more than $25.

The best condition of relative humidity for curing lemons, as determined by these experiments, lies between 80 and 90 per cent.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BULLETIN No. 495
Contribution from the Office of Public Roads and Rural Engineering
LOGAN WALLER PAGE, Director

Washington, D. C. ▼ February 14, 1917

# SPRAY IRRIGATION

By

MILO B. WILLIAMS, Irrigation Engineer

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UNITED STATES DEPARTMENT OF AGRICULTURE

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**LOGAN WALLER PAGE, Director**

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# SPRAY IRRIGATION.

By MILO B. WILLIAMS, *Irrigation Engineer.*

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## INTRODUCTION.

Within the past 10 years the spray-irrigation method has been adopted over a wide area in the United States, especially in the Atlantic Coast States from Massachusetts to Florida. Many spray-irrigation plants have been installed in the North Central States, while scattered installations can be found in practically all southern and western States.

In spray irrigation water is applied to the surface of soils and to crops in the form of small drops, spray, or mist.[1]

The first systems of spray irrigation were an outgrowth of city lawn sprinkling. It was soon demonstrated that by employing such systems small amounts of water could be applied advantageously to delicate crops, especially for supplementing an uncertain rainfall. This method also was found particularly well adapted for furnishing relatively small quantities of water to truck and small fruit crops throughout the humid region.

---

[1] Use of Water in Irrigation, by Samuel Fortier.

NOTE.—This bulletin is of special interest to truck and small-fruit growers of the eastern part of the United States.

The introduction of gas, oil, and electric power for operating pumps on the farm has provided means of elevating water to the higher lands and generating sufficient pressure to produce the desired spray. Engineers have devised systems of piping and special spray equipment for irrigating all areas by spray methods and have introduced automatic devices which reduce labor.

The object of this bulletin is to familiarize the farmer with conditions under which spray irrigation may be undertaken profitably, suggest possible water supplies, and illustrate typical pumping machinery and distribution systems, so as to aid the prospective irrigator in determining whether spray irrigation should have a place in his farm operations. It is also intended to present information necessary in working out an intelligent design and installation of a spray system.

## ECONOMIC CONDITIONS JUSTIFYING SPRAY IRRIGATION.

The cost of spray-irrigation systems depends upon the type installed as well as upon conditions peculiar to each farm. A portable outfit may cost as little as $50 per acre for the field equipment, while a stationary distribution system may cost as much as $150 per acre. To these figures must be added the cost of a main pipe line leading from the water supply to the fields and usually the cost of developing a water supply and installing a pumping plant. These additional items may bring the total outlay per acre up to two or three times the cost of the distribution system, especially on small acreage. Assuming a cost of $250 per acre on a stationary plant for a small acreage, the farmer should be able to increase his annual returns from each acre to cover approximately the following charges:

| | |
|---|---|
| Six per cent interest on $250 | $15.0 |
| Five per cent, depreciation on equipment | 12.5 |
| Two per cent, maintenance and repairs | 5.0 |
| Cost of fuel and oil at 4 cents per 1,000 gallons of water pumped for 6 acre-inches | [2]6.5 |
| Labor in irrigating, 1 man 6 days at $2 | 12.0 |
| Total overhead and operating expenses | 51.0 |

It will be noted that $51 per acre per year is necessary in return to cover overhead and operating expense incidental to the spray system. To realize a fair profit from the irrigation plant, the crop must increase in value something more than $51 per acre. In the case of berry, tobacco, and orchard crops the increase must be derive

---

[1] The subjects of lawn and greenhouse irrigation are not included in this bulletin.

[2] Cost of pumping estimated for a plant operating at 50 per cent efficiency against total head of 150 feet, using gasoline as fuel. The amount of water pumped annually assumed at 6 acre-inches as a typical duty of water in the Atlantic Coast States where spray irrigation is most extensively used. More arid sections require larger amounts.

from one main crop and a possible intercrop. On the other hand, the irrigator of truck who follows intensive culture has a chance of dividing the annual increase among three to six crops. The high cost of spray irrigation eliminates its use on many crops which respond readily to irrigation. It is possible, however, to use cheaper methods of distribution on many of these crops which are grown on land having an even surface. A combination of spray irrigation and surface methods on the same farm often can be placed under one pumping plant, as illustrated in figure 1, thereby utilizing to the fullest extent the water supply, pumping equipment, and main pipe lines. The typical farm illustrated in figure 1 indicates the use of spray irrigation on the more uneven parts where the topography is not adapted to cheaper methods but where the soil and southern slope are desirable for the growing of early and intensive truck and berry crops that will justify spray irrigation. The main feed pipe is extended to the upper and more even parts of the farm, where cheaper methods of irrigation can be applied to alfalfa, orchard, bush berries, potatoes, and other crops grown in wide rows for horse cultivation.

Truckers in the arid sections seem to favor a combination of spray irrigation and surface irrigation on the same field. The spray is used in the preparation of the seed beds, germinating seeds, and starting newly set plants. Later the crops are irrigated during the maturing and fruiting periods by the surface furrow or check methods. A portable spray equipment often meets these conditions most economically, because it can also be used for the irrigation of hot-bed and cold-frame crops.

Adequate markets, labor, and fertilizer facilities are other essentials for successful spray irrigation. Good roads and equipment for quick hauling of perishable truck and berry crops to a railway or other express service station must be assured unless some valuable annual crop, such as tobacco or onions, which can be cured on the farm, is being grown for deliberate marketing. The express service for irrigated trucking purposes must be able to deliver the products promptly and in a fresh, unwilted state to markets which require a continuous supply of high-grade vegetables. Many of the most successful users of spray irrigation are operating on small areas for the raising of only such crops as can be consumed by the local trade of a small town or community, thus simplifying the transportation question greatly.

Intensive truck or berry growing under irrigation requires a large amount of more or less experienced labor. The irrigator should manage his farm in a way which will enable him to hire men for long periods and reduce the necessity for employing many laborers for short periods. The moisture-supply control given by spray irrigation

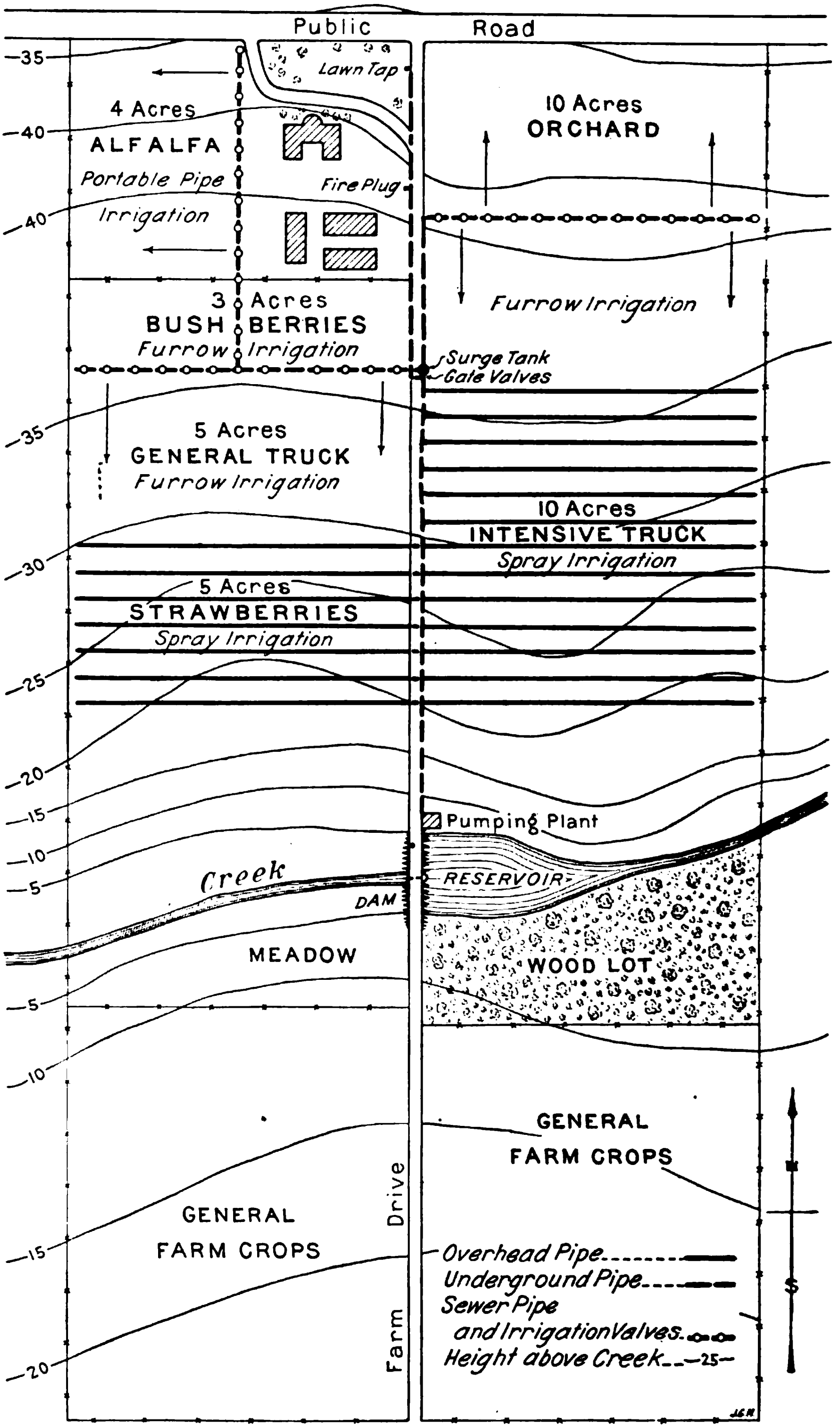

FIG. 1.—Typical 80-acre farm in humid regions, showing development of water supply by reservoir and a combination of spray and surface methods of irrigation operated from one pumping plant.

justifies the farmer in using larger amounts of fertilizers. Truckers near Philadelphia are using profitably as high as 50 tons of manure per acre each year. Therefore, proximity to manure markets is a factor of importance to be considered by the prospective spray irrigator.

## FARM CONDITIONS ADAPTED TO SPRAY IRRIGATION.

Where economic conditions are favorable to the adoption of spray irrigation, the most important question then becomes one of an adequate water supply, which will be considered under a separate heading.

Spray irrigation can be practiced to advantage on both light and heavy soils. By this method it is possible to apply evenly to sandy soils the small quantities of water which such soils will retain, without the loss of water by percolation which might occur with other methods. It is possible also to apply to heavy clay soils the small quantities of water required to soften such soils when they have baked after rains, and to apply water no faster than the soil can absorb it, thus preventing loss by surface run-off.

Lands to be irrigated should be drained as completely as possible of excess moisture. Many tile-drained fields are the most responsive to crops under spray irrigation.

Spray irrigation is practically independent of the topography of the field and can be applied to land too rolling or rough for surface methods. It is, therefore, adaptable to the irrigation of side hills on which soils tend to wash or erode.

## AMOUNT OF WATER REQUIRED FOR SPRAY IRRIGATION.

As yet, the available knowledge on the amount of water required for spray irrigation is limited, because of the comparative newness of the method and the lack of actual records on plants under a time test. The writer, however, has made estimates in several cases by recording the number of hours a plant of known capacity has been operated with effective results. In the humid regions amounts not exceeding one-fourth inch in depth often are considered a sufficient application to seed beds and young vegetables, while in the case of maturing garden crops and strawberries one-half to 1 inch may be applied. It is probable that truckers in the humid region do not use more than 6 inches in a growing season and in many seasons 4 inches or less will supplement the rainfall sufficiently. More water is required for sandy soils than for clay. A crop like the spray-irrigated citrus groves of Florida may require as much as 3 inches per irrigation. Truck and citrus growers in the arid regions apply more water than those in the humid region, probably because of a large evaporation loss. In the arid region the truck farmer is inclined to make frequent applications—every 3 or 4 days—rather than to apply the extra amount of water required in large applications which will wet below the reach of the vegetable roots, while the citrus grower applies from 4 to 8 inches each time.

For spray irrigation sufficient water to cover the land to a depth of 1 inch per week for humid regions and 1½ inches per week for arid regions is believed to be a safe estimate for designing purposes. A spray plant should be large enough to supply these amounts of water in a reasonable length of time. This is accomplished generally by installing the system to spray from one-fifth to one-half of the total acreage at one time, depending somewhat upon the type of distribution used and the available water supply.

The capacity of a pump usually is stated in gallons of water per minute of time. The following table of equivalents will assist in converting local irrigation units into gallons and acre-inches for estimating purposes:

1 acre-inch equals 27,152 U. S. gallons.
1 acre-inch equals 3,630 cubic feet.
1 acre-inch per hour equals 452.5 gallons per minute.
1 acre-inch per hour equals 1.009 cubic feet per second.

## DEVELOPMENT OF WATER SUPPLIES.

The writer will consider here only the water supplies which one or more farmers can develop, for practically all spray-irrigation installations are made by individuals and do not involve the development and transportation of distant supplies, as is common for community irrigation in the arid regions.

There are two sources of water available for irrigation—surface waters and underground waters. Surface supplies include streams, lakes, springs, and stored drainage and rain waters. Underground supplies are obtained from sumps, shallow wells, and deep wells.

### SURFACE SUPPLIES.

Streams furnish the greater portion of the water used for irrigation.

In most of the Western States methods of procedure for obtaining the right to take water for irrigation purposes from public streams have been outlined by law. Eastern States, however, have not enacted such laws, and this is apt to restrict the use of water from many streams. This is true especially where the water is being used for developing power, or where the entire flow is taken from the stream, or when a riparian owner exerts his lawful rights. These restrictions are not likely to apply to lakes unless sufficient water is taken to lower considerably the water level in the lake, or the lake feeds a stream. The right to use water from a spring originating on the farmer's land probably never will be questioned.

The use of water for spray irrigation requires a farm pumping plant. The pump should be located as near as possible to the field, so as to avoid a large discharge line, and the suction pipe should be made as short as possible. The vertical suction lift should be kept under 25 feet. The horizontal distance between pump and water should not exceed 300 feet. Where water is taken from a stream or lake having high banks it may be necessary to locate the pump on a made terrace within suction lift of the water, and in extreme cases it may be necessary to so locate both power plant and pump. Many surface supplies are surrounded by lowlands, and under such conditions the water may be carried to a pumping plant in an open ditch or large tile, permitting the pumping machinery to be located nearer the field and on firm ground. Figure 2 illustrates a pumping outfit located on a farmer's wharf before a house was built. Many eastern streams overflow, and where it is impracticable to place the pumping plant above the high-water line it is necessary to use a portable outfit which can be moved quickly. This usually is accomplished by placing the pump and engine on a set of skids or, with small plants, on wheels. In either case it is well to have a permanently located solid foundation to hold the plant when in operation. A quick method of connecting and disconnecting the discharge and suction pipes should be provided, bolted flange or flexible hose con-

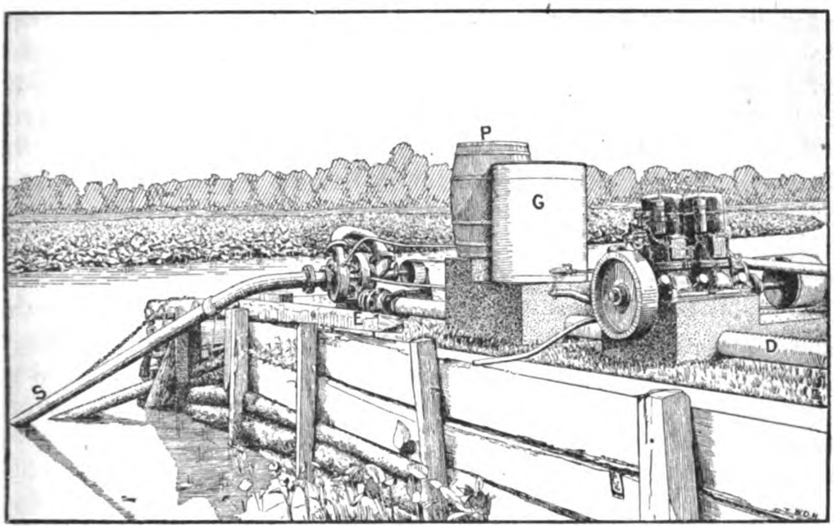

FIG. 2.—Pumping from stream with 2-stage centrifugal pump and gasoline engine, with house removed. Note lack of sharp angles in suction and discharge pipes. *D*, Discharge pipe; *E*, expansion joint; *G*, gasoline tank; *P*, priming barrel; *S*, suction pipe.

nections being commonly used. Only removable suction pipe should be placed in surface supplies which freeze in winter.

### STORAGE WATER.

In many cases excellent water supplies for spray irrigation plants are obtained from streams, drains, and wells which do not have a continuous flow of water sufficient without storage. In such cases the water may be stored in a small reservoir. Figure 1 illustrates a small stream across which an earthern dam has been built at a point where it will back considerable water over a flat area and hold it until the farmer needs to irrigate. In the Eastern States much smaller reservoirs can be used than in the arid regions, because the rains are more frequent and are sufficient to make the small streams flow every few weeks. Likewise in the more humid sections water from farm drains and rain water flowing from hillsides and roofs of buildings can be conserved by storage in reservoirs or cisterns built of clay brick or cement, and in this way many gardens may be saved in dry periods.[1] A section in eastern Pennsylvania is representative of the Eastern States where spray irrigation has developed. The writer estimates from a study of rainfall records and drought periods covering 20 growing seasons in this section that the storage of the water falling on the roof of a building during the summer months is sufficient to irrigate a garden which is three times the area of the building. The reservoir in this case would need to hold about two months' rainfall or the equivalent of 6 inches falling on the roof.

### UNDERGROUND WATERS.

Underground waters may be divided into ground and artesian. To the first belong the waters which are nearest the surface and more or less influenced by local rainfall, seepage, and droughts. The waters of the second group are confined under pressure beneath an impervious stratum, usually located at considerable depth below the surface. Such water, when tapped by boring, will rise in the well and sometimes overflow at the surface. The development of underground waters is usually more expensive than obtaining a supply from surface sources. However, when a farmer is able to obtain underground water at a reasonable depth near or in the center of the field to be irrigated the saving in cost of piping may largely offset the expense of sinking wells.

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[1] Various types of small reservoirs which would be of value to readers of this bulletin are discussed in Bulletin No. 179, of the Office of Experiment Stations, and part I of Office of Experiment Stations Bulletin No. 249. The department's supply of these bulletins has been exhausted, but copies can be obtained from the Superintendent of Documents, Washington, D. C., at a cost of 20 cents each.

A simple way to develop ground water is to dig a sump or pit in a swamp, in a sidehill-spring bog, or in seeped lands bordering a stream or canal. In many cases, where water-bearing sand or gravel can be reached near the surface, the sump furnishes a very cheap water supply which can be enlarged to considerable storage by removal of materials. Pumping from a sump or pit requires the simplest kind of machinery and is a possible source of water for spray irrigation in many of the trucking districts of the East and the surface irrigated districts of the West.

Shallow open wells are a modification of sumps, but generally are deeper and smaller in diameter. Their use as sources for irrigation water usually is limited to special cases where the materials passed through above the water stratum will stand without expensive curbing, and where the water-bearing materials are coarse, resembling gravel or porous rock, and need little screening.

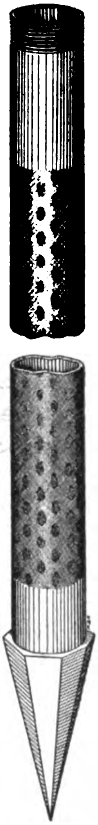
FIG. 3.—Well point.

A common way of developing ground water is by the use of one or more well points. A well point (fig. 3) consists of a section of galvanized-iron pipe which is perforated, usually with elliptical holes, and has a sharp iron plug swaged into place in one end and is threaded on the opposite end. The point is screwed into galvanized wrought-iron pipe and driven into the earth to the water-bearing stratum. Extra heavy "guaranteed" wrought-iron pipe should be used if the pipe is to be driven through hard, resistant materials. When used in coarse materials the perforations may be left uncovered, although it usually is necessary to cover the body of the point with a perforated brass jacket to prevent sand being drawn into the pump. Where very fine sand is encountered a fine mesh gauze is placed between the pipe and jacket. For irrigation wells it is advisable to use as large perforations as possible, and many wells which yield considerable sand in the beginning improve in this respect as they are pumped. Points of this type are made up to 4 inches in diameter. Two-inch points and smaller can be driven by hand through soil and sandy materials to a depth of 50 to 75 feet, while those larger in diameter usually require a machine for sinking.

Piston or plunger pumps may be connected directly to the casing of a driven well when the water comes within suction lift, which is practically 25 feet at sea level and becomes less as the altitude increases (see Table 5). Where the water draws down to a greater distance from the pump it is necessary to sink the pump in a pit, as illustrated in figures 4 and 5. Several points spaced 10 to 50 feet apart may be connected in series to one pump and in this way a considerable supply of water may be developed from small points. Centrifugal pumps should not be connected to the casing of a driven well, but if it be advisable to use such a pump it should have a separate suction pipe extending inside of the casing, as shown in figure 4. is impossible to sink a pit, some If water is below suction lift and it is impossible to sink a pit, some type of deep-well pump must be used.

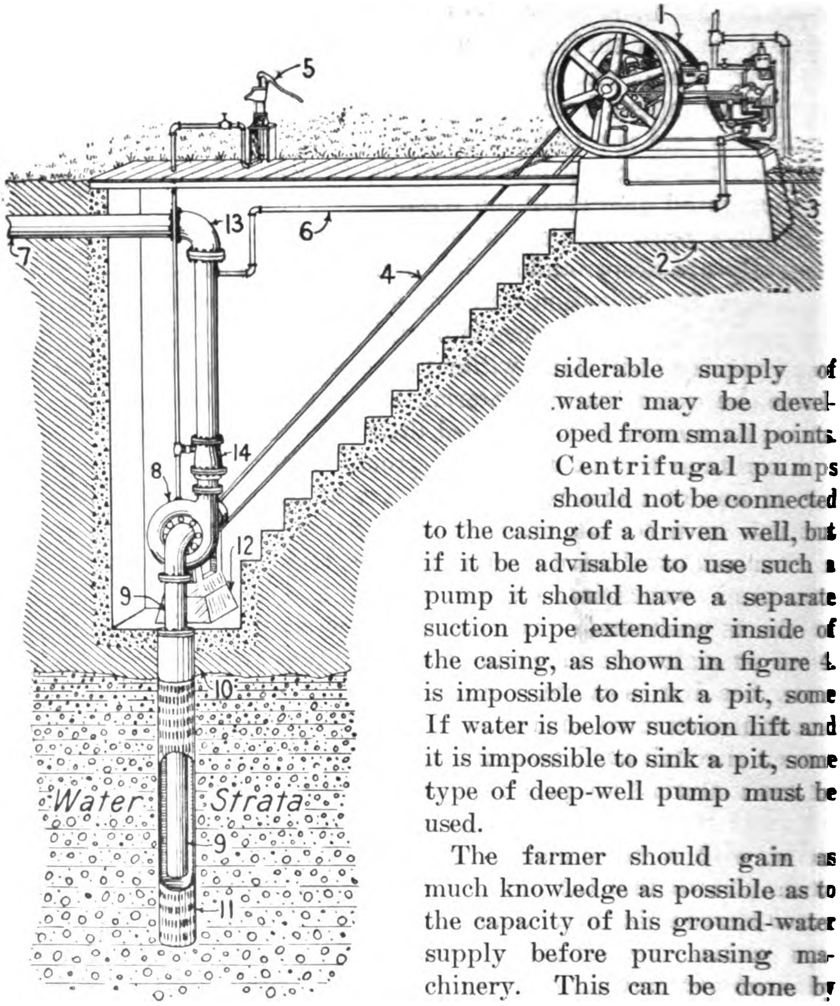

FIG. 4.—Typical installation of horizontal pump in brick or concrete pit with sloped belt. 1, Engine; 2, engine foundation; 3, fuel pipe; 4, belt; 5, priming hand pump; 6, water-cooling pipe for engine; 7 discharge pipe; 8, pump; 9, suction pipe; 10, well casing; 11, well screen; 12, pump foundation; 13, long-turn elbow; 14, check valve.

The farmer should gain as much knowledge as possible as to the capacity of his ground-water supply before purchasing machinery. This can be done by sinking a small test well to show what depth and kind of water-bearing materials are present. The test well should be pumped as near to exhaustion as is practicable and from the amount of water obtained the number and kind of wells necessary can be estimated. Two-inch and smaller wells within suction lift can be tested with a common hand pump for short periods up to a flow of 10 gallons per minute, and two men with a double-acting force pump can run tests up to a flow of 20 gallons per minute. Larger and deeper wells require special power equipment for testing.

The boring of deep wells for artesian waters should be undertaken by an expert familiar with the local underground conditions. Determining in advance the probability of obtaining artesian water sufficient for irrigation purposes is a very difficult problem. Geologists familiar with the underground formations and having records of some deep wells in the vicinity upon which to base their judgment often can render a fair opinion. However, it always is more or less a gamble until the well is completed, and a farmer should not take the risk unless he is prepared to lose.

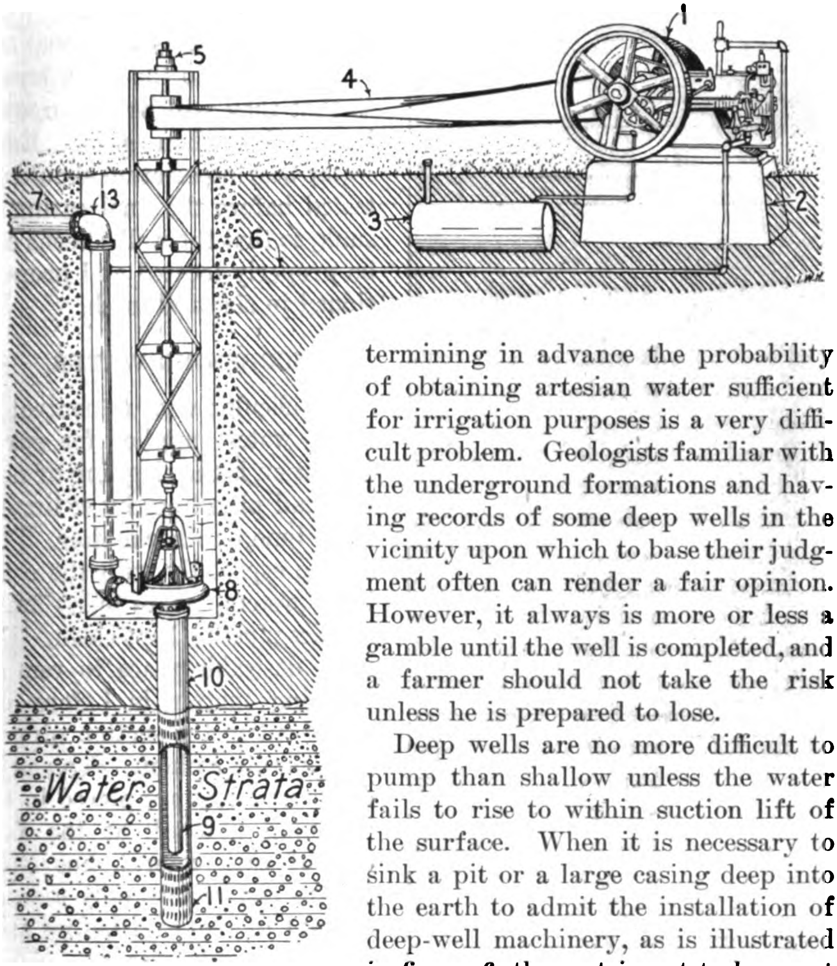

**Fig. 5.**—Typical installation of vertical-shaft centrifugal pump in pit with half-turn belt. Pump in this case is submerged in water. 1, Engine; 2, engine foundation; 3, fuel tank; 4, belt; 5, vertical shaft and bearings; 6, water-cooling pipe for engine; 7, discharge pipe; 8, pump; 9, suction pipe; 10, well casing; 11, well screen.

Deep wells are no more difficult to pump than shallow unless the water fails to rise to within suction lift of the surface. When it is necessary to sink a pit or a large casing deep into the earth to admit the installation of deep-well machinery, as is illustrated in figure 6, the cost is apt to be great and will be justified only where water can be obtained in sufficient amounts to irrigate a correspondingly large acreage.

Unlike water for drinking purposes, water for irrigation need not be pure from a bacterial standpoint. It is therefore allowable to draw on both waters near the surface and artesian supplies in the same well (fig. 6) by having the casing perforated or slotted wherever a good water-bearing stratum is intercepted. Care should be exercised to case off strata having a weak flow if strata having stronger flow are encountered in the same well, because water may be forced out of the well into the weak strata so that they will be a source of loss rather than gain. Each water-bearing stratum should be tested before the final casing is sunk, so that the well screens can be properly located and proportioned in size and mesh.

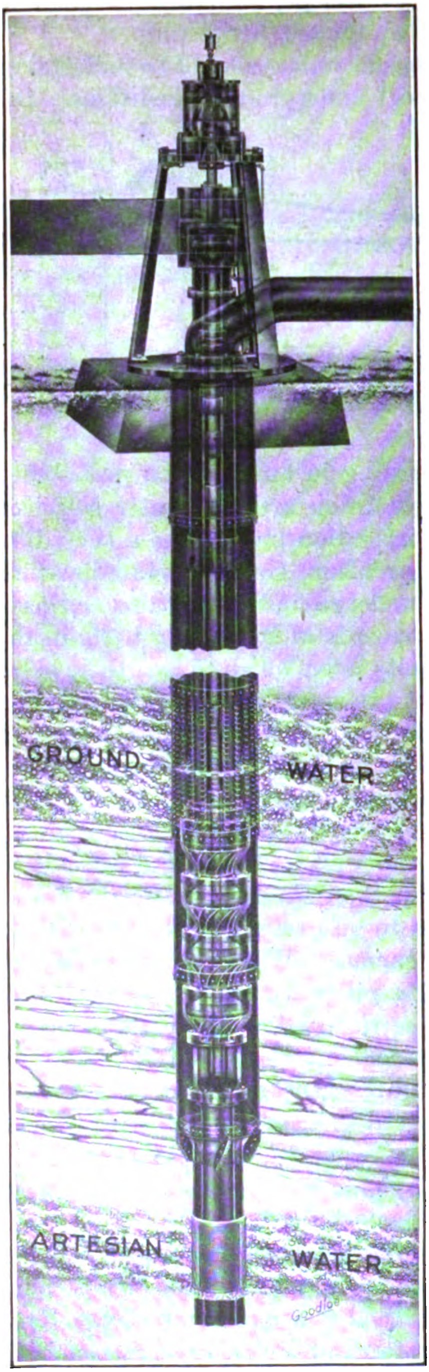

FIG. 6.—Deep-well pump in casing to permit installation of pump below ground-water level.

## SCREENING WATER.

A difficult factor to control in many water supplies for spray irrigation is the clogging of nozzles and pipe lines by sediment, moss, lime, or other matter. This is true especially with the overhead system, where many small nozzles must be kept clean. The most desirable place to remove clogging matter is before the water enters the suction pipe of the pumping plant. Screens of different forms are placed in the "turning unions" at the feed end of each lateral, but these screens can remove only a small amount of material before they in turn must be cleaned. Sands from wells or other sources may be collected to a certain extent by placing in the main pipe line an enlarged chamber similar to a pressure tank, where the velocity is checked and the sand grains settle out. Under extreme conditions it may be necessary to reservoir well waters and repump after settling. Bucket-type screens for installation in mains are also obtainable. These screens can be removed conveniently from time to time and cleaned, to prevent undue resistance to the water.

Figure 7 illustrates a screen made for streams or other surface supplies. The screen is made on a 6-inch suction pipe for a capacity of 450 gallons per minute. Four 2-inch by 3-inch cypress staves 6 feet long are placed edgewise and equi-spaced against the shell of the pipe and allowed to extend 3 feet beyond the open end of the pipe. Two pieces of cypress 2 inches thick are used for ends, one being made with a hole to slip closely over the pipe and both spiked to the ends of the staves. Two half-inch iron rods with nuts on ends are run lengthwise through the structure with adequate strap-iron ties, so that the frame is clamped together. No. 9 galvanized wire is wrapped and stapled tightly about the staves, leaving spaces of about an inch between ribs. This forms a large wire tube 12 inches in diameter and 6 feet long, to which perforated sheet brass can be soldered and nailed. The sheet brass should have circular perforations no larger than the openings in the nozzles used in the spray system. The sheets can be purchased from sheet-metal dealers. The light portions of the picture show the joints soldered to the sheets and solder covering the nail head. The metal should be upset and nailed securely to the wooden ends of the screen.

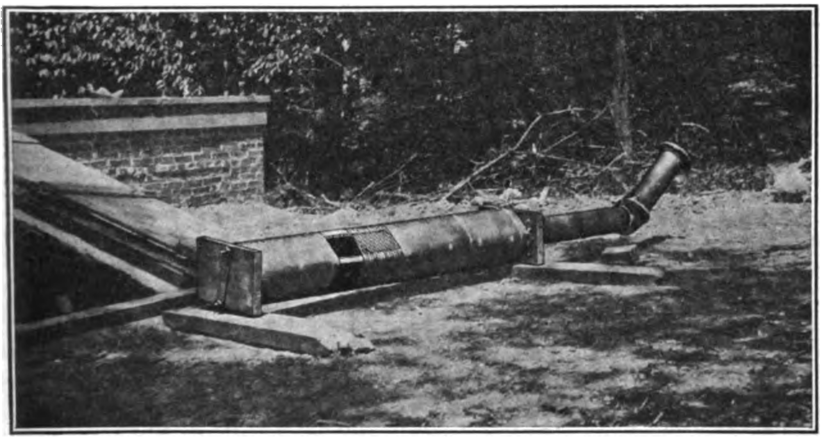

FIG. 7.—Perforated sheet-brass screen to be used in stream.

The screen described above can be used in many cases suspended in a stream, where it can be brushed clean occasionally when the pump is not running. Care should be taken not to allow the first water pumped after cleaning to go into the spray system. In shallow streams containing very fine sediment or moss the screen should be laid horizontally in a concrete bulkhead or trench made in hardpan or rock below the bottom of the channel. The space built for the horizontal screen should be large enough so that coarse sand can be placed 12 inches thick on all sides and below the current of the stream. This bed can be covered with fine sand or burlap, thus forming a suction filter which can be occasionally cleaned by removing the top covering. The filter always should be covered with an auxiliary burlap or canvas, or the stream shut out when the plant is idle, so matter will not settle on the filter and be drawn in when the pump is started.

## TYPES OF SPRAY IRRIGATION SYSTEMS.

Three types of spray irrigation construction have been adopted more or less widely for field irrigation. These are:

(1) Hose and movable-nozzle or movable lines fed from an underground pipe system and hydrant.

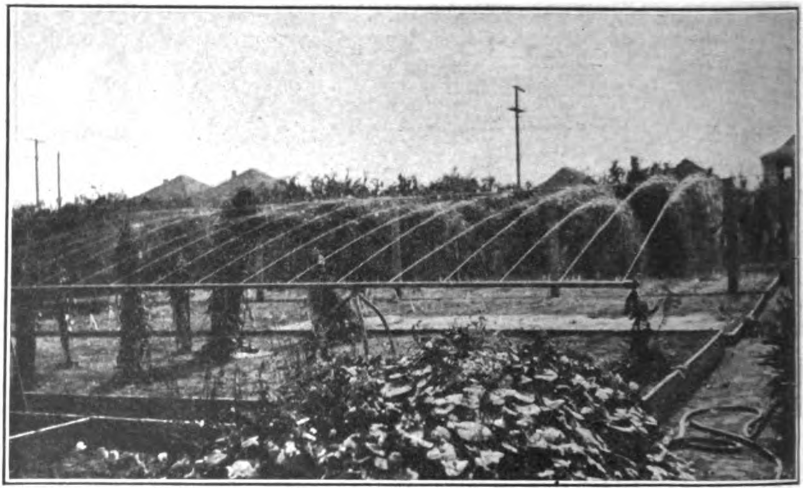

FIG. 8.—Portable spray equipment used in gardens about cold frames, hotbeds, etc. [Luther Burbank's gardens, Santa Rosa, Cal.]

(2) Circular nozzles fed from an underground pipe system.

(3) Overhead spray lines fed from an underground main feed pipe.

The hose and movable-nozzle type is used for the irrigation of cold-frame and hotbed crops, garden setting and seed beds, putting greens, public parks, lawns, small gardens, greenhouse plants, and in some Florida citrus groves. The feeder systems for this type consist of main pipe lines and branches which are laid underground to reach all portions of the field. At intervals of 50 to 200 feet, ¾ to 1¼ inch standpipes are brought to the surface and connections for hose made by means of shut-off valves threaded at the mouth for the hose unions. Lengths of rubber or canvas hose are used which will reach at least one-half the distance between standpipes, so that the entire area can be covered. There are many adjustable nozzles on the market which may be screwed to the end of a hose and made to discharge a solid stream or any degree of spray by manipulation of the nozzle parts. There are two familiar designs of nozzles for this purpose. One must be held in the hand constantly or moved about at very short intervals. The other may be set in one position and allowed to spray over a circular area.

One of the most popular portable spray arrangements is shown in figure 8. This consists of a ¾-inch pipe, 18 to 20 feet long, containing a row of small nozzles similar to those used in overhead irrigation systems. This pipe has a hose connection at one end and is supported on movable tripods or on short posts which are set permanently in the ground or attached to the cold frame or hot bed. In some instances the portable spray line contains three rows of " mist nozzles " set at about 45° angle with each other and 3 feet apart in the row. With this arrangement the pipe can be laid on top of a cold frame and a fine mist spray will cover the bed.

The hose and portable nozzle system of spray irrigation is the oldest and least efficient of spray methods. It is impossible to get an even application over the entire field or under one position of the nozzle. The constant attendance necessary and the liability of over or under irrigation makes the cost of operation high and the results dependent upon the skill of the laborer. The greatest field for this type of irrigation seems to be indoor spraying, outdoor sod lands, seed beds, and small garden plots. The first cost is the smallest of any type of spray irrigation.

## STATIONARY-NOZZLE SPRAY SYSTEMS.

Stationary nozzles fed by underground pressure systems of piping (fig. 9) have gained favor in Florida, where the sandy character of the soils makes rapid irrigation necessary. This type of equipment is being used for the irrigation of truck and citrus groves. Standard steel or wrought-iron pipe and fixtures are commonly used, but the main feed pipe sometimes is cast iron or riveted steel. Main feed pipes are run underground, leading from the water works or pumping plant into the field. Laterals are placed 12 to 15 inches below the surface in parallel lines under the entire field. At intervals of 30 to 50 feet risers to which the nozzles are attached are placed on the lateral lines so that the nozzles are spaced equidistant from each other in triangular form, as shown in figure 9. Figure 10 shows an underground section of a main feed pipe, with connections to laterals. Each lateral is controlled by a valve and in some cases a valve is placed on each riser, so that a part of the nozzles on a line may be cut off, permitting the use of longer laterals of smaller pipe. The sizes of pipe must be so proportioned and the system so designed as to give as nearly as possible a uniform pressure on all the nozzles within the area to be irrigated at one time. The risers reach a height of 4 to 6 feet above the surface for truck and extend above the trees for orchard irrigation and should be staggered, as shown in figure 9, to reduce the overlapping of spray.

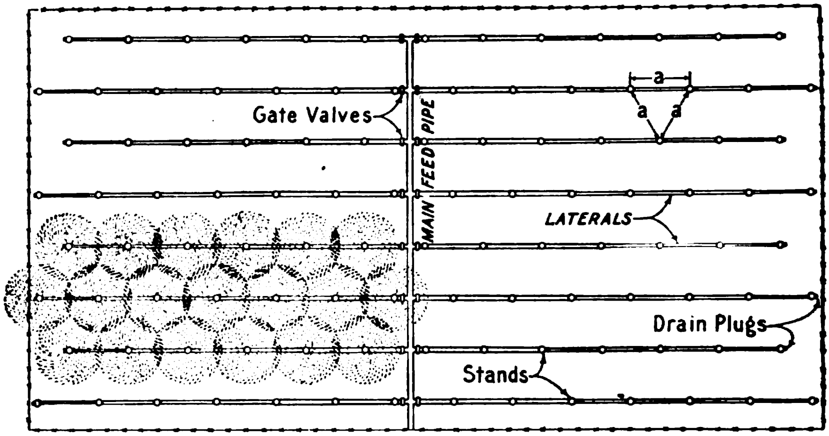

FIG. 9.—Typical plan for piping a field for stationary-nozzle spray systems, showing staggered positions of nozzles to obtain the least amount of overlapping of spray. Distances marked *a* should be equal.

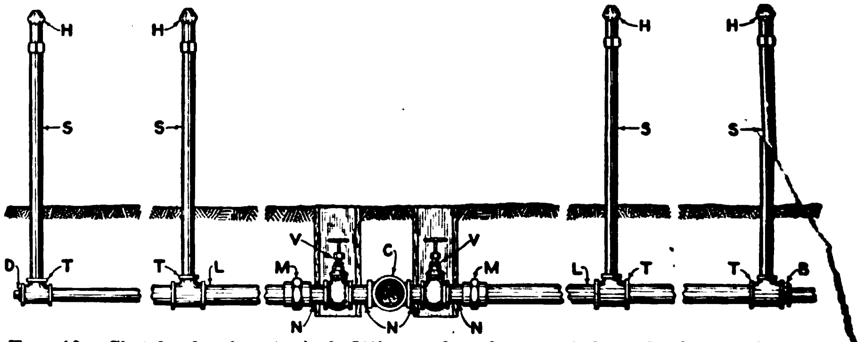

FIG. 10.—Sketch showing typical fittings of underground laterals for stationary-nozzle spray systems. *A*, Main feed pipe; *B*, bushing at reduction of pipe sizes; *C*, cross in main feed pipe; *D*, drain cock or plug; *H*, sprinkler heads or nozzles; *L*, lateral pipe lines; *M*, malleable unions; *N*, nipples; *S*, ¾-inch galvanized standpipes; *T*, malleable tees; *V*, brass gate valves.

The nozzles vary in design and generally are made of brass. Those observed in the field by the writer may be classified in three groups (fig. 11). First, solid nozzles with no movable parts; second, adjustable nozzles with parts which can be manipulated to change their capacity or form of spray; third, rotary nozzles which have movable parts to assist in the distribution of water by centrifugal force or water power.

The efficiencies of nozzles found in use were determined by a series of tests made under the direction of this office in 1909 and the results are here summarized.

A popular solid nozzle (No. 4, fig. 11) was found to have a capacity of 1.93 cubic feet per minute (14.5 gallons per minute) under a pressure of 20 pounds per square inch, and it gave a fair lateral spread of 40 feet. Under 25 pounds pressure its capacity was 2.45 cubic feet per minute (18.4 gallons per minute) with a fair lateral spread of 42 feet. The zone receiving the greatest amount of water per square foot was found to be an annular ring about 15 feet from the nozzle. This ring received about 40 per cent more water per square foot than did the surface at 5 feet or 18 feet from the nozzle.

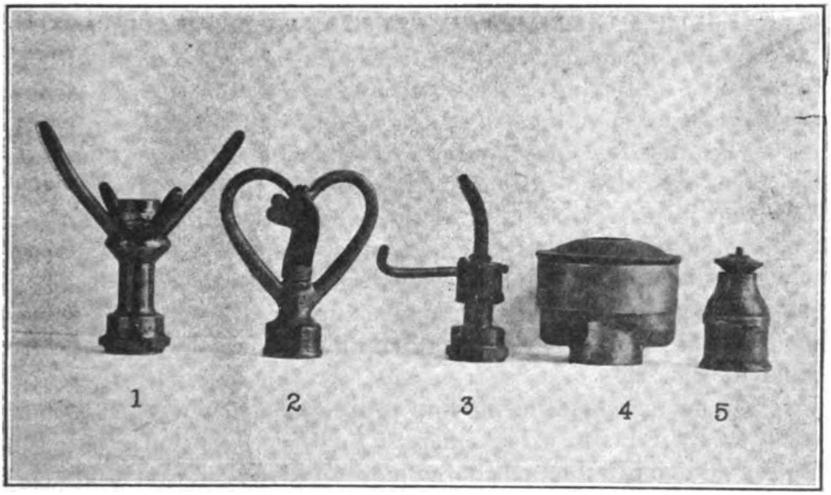

FIG. 11.—Types of circular-spray nozzles.

A popular adjustable nozzle (No. 5, fig. 11) was found to have a capacity of 0.98 cubic foot per minute (7.3 gallons per minute) under 20 pounds hydraulic pressure and a fair lateral spread of 35 feet. Under 25 pounds its capacity was 1.23 cubic feet (9.2 gallons) per minute and it gave a fair lateral spread of 38 feet. The nozzle was opened one-half turn during the above test, which gives a medium spray. A zone 12 feet from the nozzle received about 30 per cent more water per square foot than did the surface at 3 feet or 15 feet from the nozzle.

A popular rotary nozzle (No. 2, fig. 11) was found to have a capacity of 0.43 cubic foot (3.2 gallons) per minute under hydraulic pressure of 20 pounds, and it gave a fair lateral spread of 32 feet.

At 25 pounds pressure the capacity was 0.46 cubic foot (3.5 gallons) per minute with a fair lateral spread of 35 feet. The zone receiving the greatest amount of water was found to be a circular area 4 feet in diameter immediately about the nozzle. The amount received per square foot of area decreased uniformly with the distance from the nozzle.

The most striking results obtained from these tests and from similar tests with 7 other nozzles were the great ranges in capacities and the uneven distribution beneath individual nozzles. Every nozzle tested placed a large percentage of the total discharge on a small portion of the area it was supposed to irrigate. Solid and adjustable types placed the maximum amount in an annular ring having a radius about three-fourths that of the sprayed area. The rotary nozzle placed the maximum quantity of water close to the center and the quantity diminished rapidly with the distance from the nozzle.

The results of these tests, when considered in connection with the impossibility of fitting a set of circular areas together to cover a field without overlapping (fig. 9), bring out the difficulties in obtaining an even distribution of water with a stationary nozzle spray system. The cost of the system exceeds that of the hose and portable nozzle and in many cases that of the overhead equipment. The cost of operation is about the same as that of the overhead, but the efficiency and adaptability to the irrigation of delicate farm corps are generally less unless a larger amount of water is needed in a shorter time than the overhead system will supply. However, the stationary nozzles do not clog readily from rust or other particles present in many waters and operate on low pressures, which are advantages greatly in their favor, often sufficient for their adoption. This type of spray system often is considered more sightly than overhead types, while the operation is quite simple and automatic. Where it is desired to keep the cost low, block pipe can be used largely in the distribution system. The distribution is assisted greatly by a light breeze, but the field for this type of spray irrigation at present is largely confined to light soils that take water rapidly for the growing of crops and lawns that will stand a coarse spray.

## STATIONARY OVERHEAD SPRAY SYSTEMS.

The development of a stationary overhead spray system marked the beginning of rapid progress in spray irrigation for commercial crops. The original overhead system consisted of a few lengths of steel pipe set on parallel rows of posts and connected to a hand force pump. A series of small holes was drilled in the shell of the pipe through which water could be forced in the form of a spray. The holes gradually became clogged or irregular in shape, due to the rusting of the metal. The idea was conceived of replacing the holes with small brass nozzles which could be screwed into the pipe shell and would not rust. It was also found that by placing one row of nozzles in a pipe line which could be turned or rolled in bearings, a strip of land 50 feet wide could be irrigated by turning the line of nozzles to different positions through a total arc of about 90°. Special turning unions containing screens have been patented for connecting the nozzle lines to the feeder system. Likewise there are drilling machines for boring holes and tapping threads in the pipe for the nozzles. Machines for turning the nozzle lines backward and forward are being perfected and seem to be desirable for special conditions where night irrigation is practiced or spray is used for frost protection, as in Florida.

Figure 12 shows an underground section of a main feed pipe in the center of a field with connections to two nozzle lines, one on each side of a farm road, as in the typical farm (fig. 1).

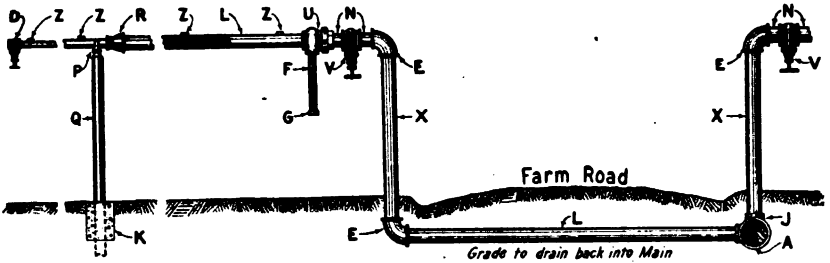

FIG. 12.—Sketch showing typical fittings for overhead nozzle lines connected to main feed pipe and method of crossing a farm road. *A*, Main feed pipe; *D*, drain cock or cap; *E*, elbow; *F*, handle for turning nozzle lines; *G*, cap on handle; *J*, side-outlet tee; *K*, concrete base for pipe post; *L*, nozzle-line pipe; *N*, "long" nipples; *P*, pipe hanger; *Q*, 1¼-inch pipe post; *R*, reducing cocket; *U*, turning union; *V*, brass gate valve; *X*, risers to nozzle lines; *Z*, nozzles.

## LOCATION AND CONSTRUCTION OF OVERHEAD SPRAY SYSTEMS.

Each overhead spray plant should be modeled to fit the field and conditions under which it is to operate. Assuming that water supply has been developed, there are three major parts to any system which should be considered in the order given. First, type and location of nozzle lines; second, type and location of main feed pipe; third, type and location of pumping plant. The nozzle lines should take the direction most desirable to cultivate the field, so that the crop rows will be parallel to the rows of supports. In general, nozzle lines should run perpendicular to the main feed pipe. The entire field system should be designed to use the minimum amount of large pipe, which generally means to run the main as straight as possible, keeping the nozzle lines in sizes not to exceed 1½-inch pipe.

The sizes of pipe to use in a nozzle line depends upon the length. The end connecting with the feed pipe must be sufficiently large to carry the full head of water. As the water is diminished by each nozzle the pipe can be reduced in size, finishing with a ¾-inch pipe at the extreme end. The customary sizes of pipe used for the nozzles now on the market are set forth in Table 1.

TABLE 1.—*Sizes of pipe used for nozzles now on the market.*

| | Total length of line. | ¾-inch pipe. | 1-inch pipe. | 1¼-inch pipe. | 1½-inch pipe. | 2-inch pipe. |
|---|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| Nozzle No. 1, outdoor, 4 feet apart. | 150 | 150 | ........ | ........ | ........ | ........ |
| | 200 | 130 | 70 | ........ | ........ | ........ |
| | 250 | 100 | 150 | ........ | ........ | ........ |
| | 300 | 100 | 150 | 50 | ........ | ........ |
| | 400 | 90 | 160 | 150 | ........ | ........ |
| | 500 | 90 | 160 | 150 | 100 | ........ |
| | 600 | 90 | 160 | 175 | 175 | ........ |
| | 700 | 90 | 160 | 175 | 175 | 100 |
| Nozzle No. 2, outdoor, 4 feet apart, or No. 1, 3 feet apart. | 150 | 115 | 35 | ........ | ........ | ........ |
| | 200 | 100 | 100 | ........ | ........ | ........ |
| | 250 | 90 | 100 | 60 | ........ | ........ |
| | 300 | 90 | 100 | 110 | ........ | ........ |
| | 400 | 80 | 100 | 120 | 100 | ........ |
| | 500 | 75 | 100 | 120 | 120 | 85 |
| | 600 | 75 | 100 | 120 | 120 | 185 |

Nozzle lines are spaced such distances apart as will best fit the field within a range of 50 to 56 feet. The type of nozzle line depends principally upon the method used for supporting the pipe. The three popular methods are: On tall posts, on short posts, or on cables suspended from high posts.

### TALL-POST TYPE.

When tall posts are used they are set in the ground 2½ to 3 feet and cut off about 6½ feet above the ground (fig. 13). These posts are spaced 15 to 20 feet apart and the nozzle line placed on the tops in roller bearings in the case of long lines and between nails in short lines. If the post is of wood it should be not lighter than 4 by 5 inches, but a round post 5 to 6 inches in diameter will serve as well. A more durable but expensive post can be made from a 1 or 1¼-inch steel pipe set in a base of concrete 6 inches in diameter and 2 feet deep (fig. 12). Special concrete posts also make excellent supports.

Where wooden posts are used it is advisable to treat the part going into the ground with a good grade of paint, tar, or creosote, to help preserve the wood. The treatment should extend 6 inches above the ground surface.

The tall posts permit the passing of horses or men under the pipe and obviate obstruction to cultivation. This is the most popular method and makes a good appearance when the posts are carefully lined and cut off at the tops so that the pipe will lie straight, or uniformly curved with the surface of the ground.

### SHORT-POST TYPE.

If short posts are used they are set in the ground 2 to 2½ feet and cut off 1 to 3 feet above the surface. They are spaced 18 to 20 feet apart and the nozzle line placed on top between nails or in roller bearings. A 4 by 4 inch post serves well for this type, but should be treated as are tall posts. This construction is the least expensive, but may cause a somewhat closer spacing of nozzle lines if a low hydraulic pressure is to be used. This type also is somewhat in the way of cultivation and is not efficient for tall-growing crops. When nozzle lines are made portable on short posts, posts may be made of ¾-inch pipe sharpened and fastened to the nozzle line so that supports are moved with the pipe.

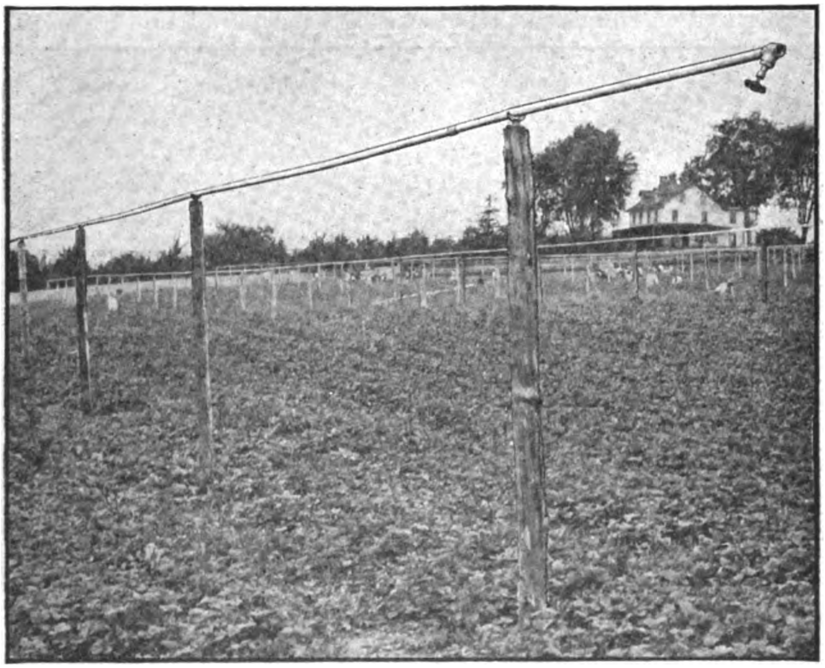

FIG. 13.—Overhead spray nozzle lines mounted on wooden posts 6½ feet above the ground. [Farm of Granville W. Leeds, Rancocas, N. J.]

### HIGH POSTS AND CABLE-SUSPENSION TYPE.

Where high posts and cable suspension is used the posts are spaced from 100 to 200 feet apart and the nozzle line suspended from a tight cable or wire strand which takes the form of a catenary curve between posts (fig. 14). Telephone poles 8 to 10 inches at the base and 6 to 8 inches at the top can be used. A length of 2½-inch steel pipe which may be filled with concrete makes a more substantial post.

Wooden posts or black-steel posts should be painted with tar or treated with creosote. The posts should be considerably higher than the nozzle line, depending upon the distance between posts and the weight to be supported. It is well to set the bases of the posts in beds of concrete about 18 inches in diameter and 3 feet deep. The end posts and cables must be well anchored with guys fastened to wooden or concrete "deadmen." A 5-foot anchor rod should be attached to the deadman and extended above the surface with an eye where a turnbuckle and a guy wire can be attached, as shown in figure 15. Single guys are used where the tops of the end posts of several lines can be connected with a guy wire perpendicular to the nozzle lines, otherwise double guys should be used. The deadman should be at least a distance equal to one-third the height of the post from the post's base.

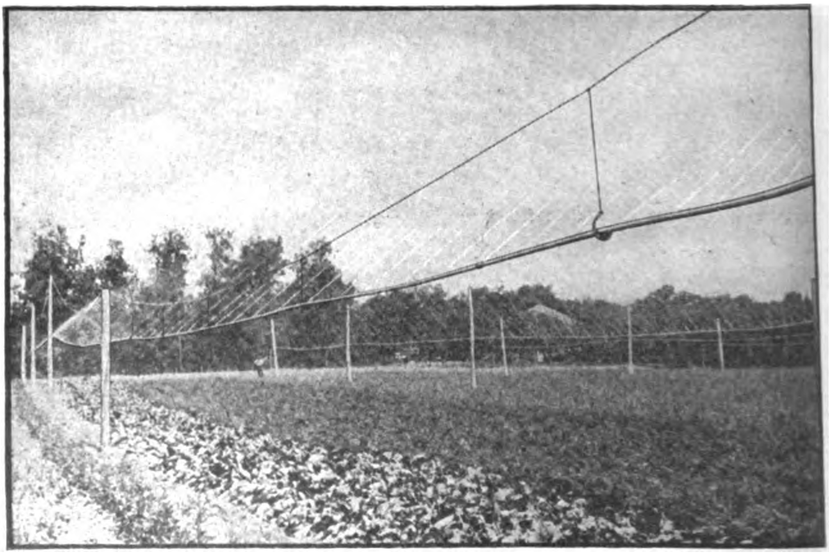

FIG. 14.—Overhead spray-nozzle lines suspended from high posts by cable line.

The weight of cable to use for each particular case should be determined by an engineer familiar with this construction after he has been given the length of the line, the weight to be supported, and the spacing of posts. The manufacturers of cables are prepared to recommend necessary size and kind of cable. It is well to use double galvanized materials, which will be lasting. The pipe is suspended from the cable with short lengths of about No. 14 galvanized wire spaced 15 to 18 feet apart. The nozzle line is hung in special galvanized-metal hooks containing rollers to make the pipe turn easily, and an eye for attaching to the suspension wire. The nozzle line can be graded by adjusting the lengths of the suspension wires.

The chief advantage in the suspension system is the reduction of obstruction in the field, and where it is well constructed the plant will be very durable. This type costs more than the others and is not as commonly used as the simple post supports. The cleaning of nozzles on highly supported lines is difficult, so pipe should be kept within reach.

### NOZZLE LINES.

The pipe in the nozzle lines should be galvanized wrought iron or steel. The galvanizing not only makes the system longer lived, but reduces oxidation of the metal, which, if not prevented, tends to form scales that fill the nozzles.

A nozzle line is connected with the main feed pipe by means of a riser cut the proper length to act as the first post in the line. In the longer lines it is well to have the riser of 1½-inch pipe, which will make a strong support even if this is larger than the first section of nozzle line. An elbow is placed on top of the riser, and into this is screwed a long nipple which terminates in a standard brass gate valve (fig. 12). To reduce friction this valve should be of the same size as the standpipe. The turning union is screwed into the opposite side of the valve. The union most commonly used contains a screen for catching sediment from the passing water. A capped handle 2 feet long, made of ¾-inch pipe, is screwed into the side of the union. This serves as a lever for turning the nozzle line in its bearing as well as giving entrance to the union for flushing the screen.

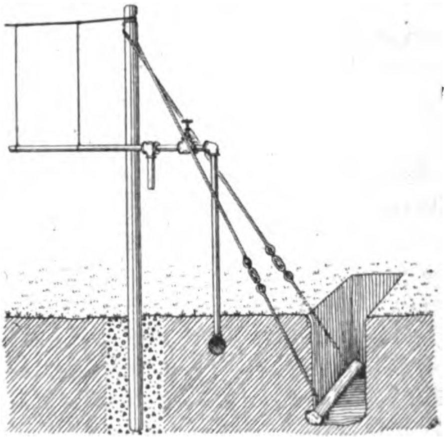

FIG. 15.—Anchorage for suspended overhead nozzle lines, showing location of "deadman" and turnbuckles.

Reducing couplings, and not bushings, should be used for connecting the different pipe sizes. A ¾-inch valve or a cap should be placed over the extreme end of the nozzle line. This permits flushing out the line at any time by opening the valve or removing the cap. (See fig. 13.)

### MAIN FEED PIPES.

There are several kinds of pipe adaptable for spray irrigation mains—steel or wrought iron with threaded joints, riveted steel with flanged or bolted joints, cast iron with lead or bolted joints, and wood-stave pipe.

### STEEL OR WROUGHT-IRON PIPE.

Steel or wrought-iron pipe with threaded joints which screw together, used for main pipe lines, is the common water or steam pipe used exclusively in all plumbing. This comes in random lengths of about 18 feet long and in all diameters. It is the best to use for mains up to 5 inches diameter. Larger sizes are expensive and more difficult to handle in the field. It is advisable to use galvanized-steel pipe throughout. However, black-iron fittings cost less than galvanized and outlast the galvanized pipe. Some irrigators prefer black "guaranteed" pure wrought-iron pipe for mains. This costs about the same as galvanized steel and is more durable than black steel. Pipe 2 inches and over in size should be cut, threaded, and marked to fit each section in the shop, as it is difficult and expensive to do this in the field. Where a main intersects a nozzle line a tee is used in the main and the standpipe for the nozzle line is screwed into the tee direct (fig. 12).

### RIVETED STEEL PIPE.

Riveted steel pipe, made of sheet metal either straight or spiral-riveted into a pipe, can be purchased in sizes of 3-inch diameter and over. The thickness of metal used depends upon the pressure which the pipe must withstand and somewhat upon the length of life desired. The riveted pipe is treated with an asphalt-tar solution or mineral paint or is galvanized. The unprotected steel pipe never should be used in irrigation construction. The small sizes, from 3 to 8 inches, should be galvanized and the larger coated if not galvanized.

Riveted pipe can be made in any lengths convenient to handle in the field; 20 to 25 feet is the usual section. Two types of joints are used for riveted steel pipe, i. e., flange and gasket or bolted. The flanged joint is rigid and the line must be straight, unless the pipe is made curved in the shop. The bolted joint permits a small angle in the line at each joint, and generally is the most adaptable for irrigation mains. The bolted joints also act as expansion joints, which is advantageous in long lines. In all straight mains of great length some design of expansion joint must be used to care for expansion and contraction caused by changes in temperature.

Laterals or nozzle lines can be connected to riveted steel pipe mains by the use of a special tee. Where bolted joints are properly spaced in the mains the cast-iron collars of the joints can be tapped for the connections. It is also possible to have special flanges or saddles into which the lateral can be screwed, riveted to the pipe in the shop.

Riveted steel pipe is more economical where large sizes are needed and long shipments must be made, as this pipe is light in weight

It is easy to lay, but its comparative shortness of life is its chief disadvantage.

### CAST-IRON PIPE.

Cast-iron pipe, such as is commonly used in city water systems, is adaptable for the larger installations of spray systems. Standard cast-iron pipe, 4 inches and larger in diameter, is made in 12-foot lengths. It is also made in two weights for 100 and 200-foot pressure heads. Usually the lighter weight is sufficient for spray irrigation systems, especially after the field is reached. Joints are made by pouring hot lead into the bell end of each section, or a bolted joint may be used. In some instances a rich mixture of cement mortar may be driven into the joint instead of lead. Connections for the laterals or nozzle lines are made with special fittings, or the shell of the pipe may be tapped and a saddle of metal or concrete placed around the connection.

The advantages of cast-iron pipe are its long life, comparative cheapness in the larger sizes where freight hauls are short, and ease of laying. The disadvantages are tendency to rust and scale after lying idle, heavy weight for long freight hauls, and need of special equipment for laying and tapping.

### WOOD-STAVE PIPE.

Wood-stave pipe made of durable fir or redwood is used extensively for pressure conduits in the Western States. The pipe is built of carefully machined staves, which are held in place by metal bands. This pipe can be secured in sizes 2 inches in diameter and larger. The smaller sizes usually are made in sections and joined together by means of a collar or sleeve. Large sizes may be built continuously in the field. Connections for laterals are made easily by metal saddles. The metal bands should be heavily galvanized and the wood treated with a preservative. The advantages of wood pipe are its comparative cheapness in first cost and smoothness of bore. Provision should be made to keep the pipe full of water, otherwise the staves will dry and decay.

## TYPES OF PUMPS FOR SPRAY IRRIGATION.

All spray irrigation plants require power pumping equipment unless pressure can be supplied from an elevated source or municipal water works. To generate a spray requires a high-pressure pump producing 25 to 40 pounds pressure on the nozzles in addition to elevating the water to the field. The two types of pumps used for this purpose may be classified under "displacement" and "centrifugal" pumps.

Displacement pumps are those which force water by means of a piston or plunger traveling backward and forward in a close-fitting cylinder. Centrifugal pumps are those which force water by means of an impeller or fanned wheel revolving at a high speed in a close-fitting shell or case.

### DISPLACEMENT PUMPS.

Displacement pumps are divided into groups according to the number of cylinders they contain, while each group can be subdivided into single-acting or double-acting pumps, depending on whether the water is forced during the forward stroke only or during both the backward and forward strokes of the piston. For spray irrigation one and two cylinders should be double-acting. Three cylinders should be single-acting.

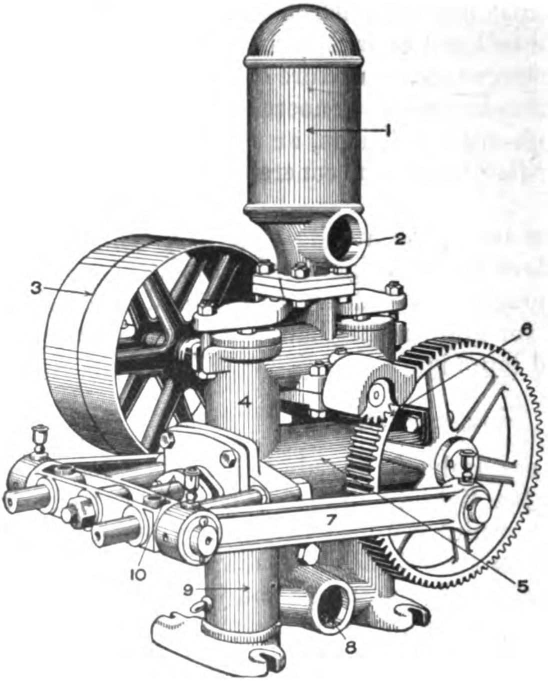

FIG. 16.—Typical simplex, double-acting displacement pump. 1, Air chamber; 2, discharge opening; 3, tight and loose pulleys; 4, valve chamber; 5, cylinder; 6, gear; 7, connecting rod; 8, suction opening; 9, base; 10, packing gland.

A typical one-cylinder or simplex pump is shown in figure 16, with its principal parts numbered and named. These pumps are adapted for spray systems requiring up to 114 gallons per minute, and will work against a total head of 175 feet. This type of pump is adapted to small plants where the water can be obtained within suction lift, and may be installed on the surface or in a pit, and driven by belt or gear connection to power. Single-cylinder double-acting pumps are adapted also to deep-well pumping where the cylinder is suspended in the well and operated from the surface by a power working head, of which figure 17 is a typical design for small plants.

Duplex or two-cylinder pumps usually are constructed with two cylinders lying horizontally on a common base, which also holds a power working head. The duplex pumps are adapted to large plants for pumping from surface supplies to any height. They can be driven by either belt or gear connection to the power.

Triplex or three-cylinder pumps are adapted for pumping water from surface supplies to any height of lift for the larger plants. For special well conditions triplex pumps are designed for the three cylinders to work in a pit while the power working head remains on the surface. These also can be driven by belt or gear connection to the power.

Small displacement pumps of the belt-driven types should be equipped always with tight and loose pulleys to aid in starting the engine. For the same reason large outfits should be equipped with friction-clutch pulleys on the shaft if belt driven and shaft clutches if gear connected. Clutches are not so essential where electric power is used for either small or large plants. All displacement pumps should be equipped with ample air chambers to act as cushions in absorbing the pulsations of the water. Relief valves or by-passes should be placed in the discharge pipes to prevent breaking the pumps or engines should all or a part of the spray lines be shut off.

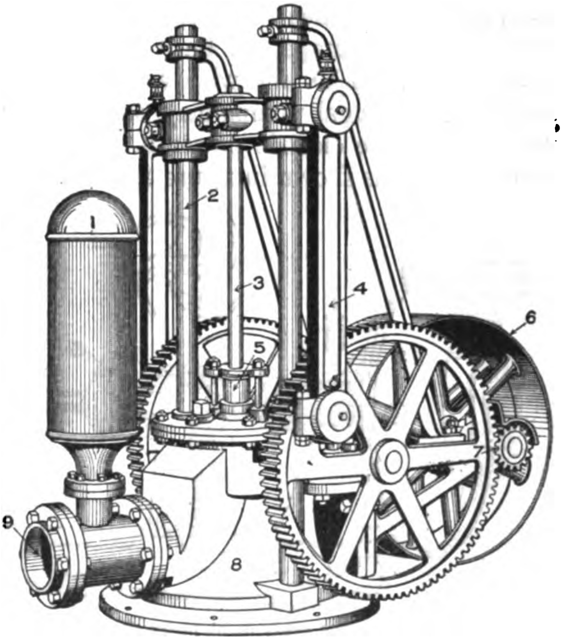

FIG. 17.—Typical power working-head for deep-well pumps having a 24-inch stroke. 1, Air chamber; 2, crosshead guides; 3, piston rod; 4, connecting rod; 5, packing gland; 6, tight and loose pulleys; 7, gear wheel; 8, base; 9, discharge opening.

### CENTRIFUGAL PUMPS.

Centrifugal pumps can be classified as volute and turbine types. Each type can be divided further into pumps having one, two, etc., stages, according to the number of impellers contained. Figure 18 shows a typical single-stage volute-type pump with exposed impeller. Single-stage pumps are built in both volute and turbine types for any lift practical for spray irrigation; however, the possible lift depends greatly upon the speed of the impeller, which usually makes it desirable to adopt a two-stage pump when the lift exceeds 100 to 150 feet, which can be run at practically one-half the speed of a single stage. Figure 19 shows a typical two-stage turbine pump with a split shell which allows easy access to the impeller and bearings. The volute type usually is cheaper in first cost than the turbine, but the latter is more efficient.

Centrifugal pumps can be used for spray irrigation to lift water from surface supplies (fig. 2), shallow wells (fig. 4), or deep wells (fig. 6). The pumps are built with horizontal shafts, as shown in figures 18 and 19, and with vertical shafts, as shown in figures 5 and 6. Centrifugal pumps may be driven by belt connection to the power or, where electric power is available, the motor can be connected direct, as shown in figure 18.

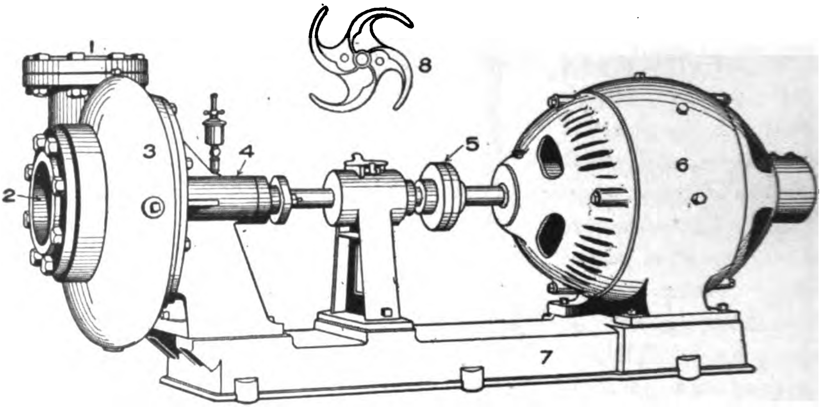

FIG. 18.—Single-stage centrifugal pump direct connected to electric motor, showing an open-type impeller. 1, Discharge; 2, suction; 3, pump volute or case; 4, stuffing box; 5, coupling; 6, electric motor; 7, base; 8, impeller.

The chief advantages of centrifugal pumps compared with displacement for spray irrigation are their low first cost for the same capacity, their simplicity, and the few wearing parts. A centrifugal pump also fits itself readily to pressure changes of a spray system without the use of a by-pass or relief valve. One spray line or all may be shut off to suit the needs of the farmer while the pumping plant is running, without ill effects to the machinery.

Centrifugal pumps must have a free suction intake and usually should not be attached directly to well casings, but should have a separate suction pipe extending into the water well below suction lift. All centrifugal pumps must be full of water before they will draw through the suction. All air should be excluded from the suction pipe and pump case before starting. A common method is to pump the air out with an ordinary hand pump, which causes the water to rise in the suction pipe and fill the pump. The hand pump must be a vacuum pump when placed above suction lift of the water level (see Table 5). In this case an air-tight check valve is placed in the discharge pipe just above the centrifugal pump to prevent air entering through the discharge pipe. The smaller centrifugal pumps can be purchased with a "hand primer" built into the suction and are adapted to low suction lifts. Figures 5 and 6 show centrifugal pumps submerged in water, so that the case is always full and needs no priming. Figure 2 illustrates how the pump can be primed from a barrel or any elevated source. In this case it is necessary to have a check valve or foot valve in the suction pipe below the water level to prevent the priming water from running out through the suction pipe. A check valve is preferable to a foot valve because of the ease in entering and less resistance to the water. When the pump is started the priming barrel will be refilled if the valve is left open for a short time.

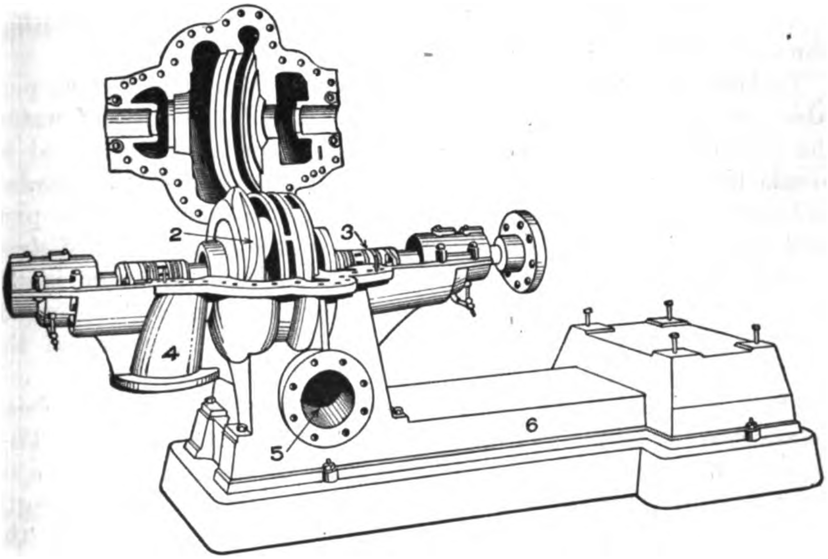

FIG. 19.—Typical two-stage split-case centrifugal pump. 1, Top half of split case, raised; 2, impellers; 3, packing; 4, suction; 5, discharge; 6, base.

## THE DESIGNING OF SPRAY IRRIGATION SYSTEMS.

Every spray irrigation system can be divided into three parts, which must be considered in their proper relation to each other in the design of a plant. First, the distribution-pipe system, which applies the water directly to the crops through some type of nozzle; second, the main feed pipe, which conveys the water from the source to the distributaries; third, the pumping equipment, which lifts the water and develops the pressure, unless the water and pressure are obtained from a gravity or municipal supply.

The distribution system should be laid out to use the minimum amount of large pipe for both distributaries and main feed pipe. The laterals or nozzle lines should run in a direction which will give the least amount of obstruction to the cultivation of the field in the most efficient manner. The field should be laid off in irrigation blocks or units, a unit representing the area to be irrigated at one time. The unit should be of a desirable length for the kind of crops to be irrigated. Where possible, it is advisable to divide the field by the irrigation system into blocks which will make the estimating of acreages easy when arriving at the amount of seed and fertilizer required or determining yields. This is done usually by having a convenient fraction of an acre under each spray line or by having the crop rows a length which will make each rod or yard in width a known fraction of an acre.

To keep the cost of a spray distribution system as low as possible, yet obtain a good uniform pressure and distribution of water, the sizes of pipes must be proportioned properly. Each lateral or nozzle line must be proportioned in size according to the number and capacity of the nozzles used. The main feed pipe must be proportioned to carry the total amount of water to the most distant irrigation unit and then be reduced in size as the water is decreased by each nozzle line within the irrigation unit. The water required to run an irrigation unit determines the capacity of the pumping equipment.

There is a resistance to water flowing in pipe which has been determined by experiments and is called "friction head." This friction is in proportion to the roughness of the inside surface of the pipe and varies with the velocity of the water and the length and diameter of the pipe line. The greater the friction of the water in the pipe the more power is required to pump the water; therefore, there is a logical size of pipe to use for each quantity of water and set of conditions to keep this frictional factor within reasonable limits. Table 2 shows the quantities of water which should be carried in different sizes of iron pipe.

TABLE 2.—*Amount of water different sizes of straight iron pipe will carry without excessive friction for spray irrigation.*

| Diameter of pipe. | Quantity per minute. | Diameter of pipe. | Quantity per minute. |
|---|---|---|---|
| | *Gallons.* | | *Gallons.* |
| ½ inch | 1 to 2 | 3 inches | 75 to 125 |
| ¾ inch | 3 to 4 | 3½ inches | 125 to 175 |
| 1 inch | 5 to 8 | 4 inches | 175 to 250 |
| 1¼ inches | 9 to 16 | 5 inches | 250 to 400 |
| 1½ inches | 17 to 25 | 6 inches | 400 to 600 |
| 2 inches | 25 to 45 | 7 inches | 600 to 900 |
| 2½ inches | 45 to 75 | 8 inches | 900 to 1,200 |

Table 3 shows the number of feet which should be added to the lift for each 100 feet of straight pipe to overcome the friction and to obtain the total lift which must be pumped against. Tables 2 and 3 should be used by the farmer for estimating purposes, while the proportioning of the pipe sizes in the final design should be done by an irrigation engineer or by the manufacturers of the spray equipment used.

TABLE 3.—*Number of feet to be added to the vertical lift for each 100 feet of common iron pipe to overcome "friction head."*

[Based on Williams-Hazen formula, using a coefficient of 100.]

| Gallons per minute. | Size of pipe. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ¾-inch. | 1-inch. | 1¼-inch. | 1½-inch. | 2-inch. | 2½-inch. | 3-inch. | 3½-inch. | 4-inch. | 5-inch. | 6-inch. | 7-inch. | 8-inch. |
| | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| 5 | 10.5 | 3.25 | 0.84 | | | | | | | | | | |
| 6 | 14.7 | 4.55 | 1.20 | | | | | | | | | | |
| 8 | 25.0 | 7.80 | 1.59 | 0.95 | | | | | | | | | |
| 10 | 38.0 | 11.70 | 2.06 | 1.43 | 0.50 | | | | | | | | |
| 12 | | 16.40 | 4.30 | 2.01 | .70 | | | | | | | | |
| 14 | | 22.00 | 5.70 | 2.68 | .94 | 0.32 | | | | | | | |
| 16 | | | 7.30 | 3.41 | 1.20 | .41 | | | | | | | |
| 18 | | | 9.10 | 4.24 | 1.49 | .50 | | | | | | | |
| 20 | | | 11.10 | 5.20 | 1.82 | .61 | 0.25 | | | | | | |
| 25 | | | 16.60 | 7.80 | 2.73 | .92 | .38 | | | | | | |
| 30 | | | 23.50 | 11.00 | 3.84 | 1.29 | .54 | | | | | | |
| 35 | | | | 14.7 | 5.10 | 1.72 | .71 | 0.32 | | | | | |
| 40 | | | | 18.8 | 6.60 | 2.20 | .91 | .41 | | | | | |
| 45 | | | | 23.2 | 8.2 | 2.76 | 1.15 | .51 | | | | | |
| 50 | | | | | 9.9 | 3.32 | 1.38 | .62 | 0.84 | | | | |
| 60 | | | | | 13.9 | 4.65 | 1.92 | .89 | .47 | | | | |
| 70 | | | | | 18.4 | 6.20 | 2.57 | 1.11 | .63 | 0.21 | | | |
| 80 | | | | | 23.7 | 7.90 | 3.28 | 1.46 | .81 | .27 | | | |
| 90 | | | | | | 9.80 | 4.08 | 1.80 | 1.00 | .34 | | | |
| 100 | | | | | | 12.00 | 4.96 | 2.22 | 1.22 | .41 | | | |
| 120 | | | | | | 16.80 | 7.00 | 3.10 | 1.71 | .58 | 0.23 | | |
| 140 | | | | | | 22.30 | 9.2 | 4.20 | 2.28 | .76 | .30 | | |
| 160 | | | | | | | 11.8 | 5.25 | 2.91 | .98 | .36 | | |
| 180 | | | | | | | 14.8 | 6.30 | 3.61 | 1.22 | .47 | | |
| 200 | | | | | | | 17.8 | 7.7 | 4.40 | 1.48 | .56 | 0.28 | |
| 220 | | | | | | | 21.3 | 9.6 | 5.2 | 1.77 | .69 | .33 | |
| 240 | | | | | | | | 11.6 | 6.2 | 2.08 | .83 | .39 | 0.22 |
| 260 | | | | | | | | 13.3 | 7.2 | 2.41 | .95 | .47 | .25 |
| 280 | | | | | | | | 15.2 | 8.2 | 2.77 | 1.10 | .53 | .28 |
| 300 | | | | | | | | 17.8 | 9.3 | 3.14 | 1.26 | .62 | .33 |
| 350 | | | | | | | | 22.6 | 12.90 | 4.19 | 1.68 | .82 | .45 |
| 400 | | | | | | | | | 16.0 | 5.40 | 2.10 | 1.03 | .56 |
| 450 | | | | | | | | | 19.8 | 6.70 | 2.52 | 1.24 | .71 |
| 500 | | | | | | | | | 24.0 | 8.10 | 3.15 | 1.50 | .84 |
| 550 | | | | | | | | | | 9.6 | 3.70 | 1.81 | 1.01 |
| 600 | | | | | | | | | | 11.3 | 4.35 | 2.18 | 1.20 |
| 650 | | | | | | | | | | 13.2 | 4.90 | 2.50 | 1.40 |
| 700 | | | | | | | | | | 15.1 | 5.80 | 2.90 | 1.60 |
| 750 | | | | | | | | | | 17.2 | 6.60 | 3.30 | 1.78 |
| 800 | | | | | | | | | | 19.4 | 7.50 | 3.65 | 2.00 |
| 850 | | | | | | | | | | 21.7 | 8.40 | 4.20 | 2.26 |
| 900 | | | | | | | | | | | 9.20 | 4.80 | 2.50 |
| 950 | | | | | | | | | | | 10.1 | 5.10 | 2.80 |
| 1,000 | | | | | | | | | | | | 5.60 | 3.10 |

Table 4 is a bill of materials for the typical farm (fig. 1, p. 4), and is given as an example of a form for obtaining quotations on spray irrigation equipment (see also fig. 12, p. 19). "Run" means a certain amount of pipe which will give a desired length when screwed together. Pipe less than 2 inches in diameter can be cut in the field, hence the actual number of feet required is stated for such pipe. "Location" refers to the location in the field. Nozzle lines are assumed to be 630 feet long on each side of the farm road. Pipe posts are assumed to be set 18 feet apart, and 9 feet long, to support nozzle lines 6½ feet above the surface.

TABLE 4.—*Bill of materials.*

| Amount. | Size. | Item. | Location. |
|---|---|---|---|
| | *Inches.* | | |
| 1 run, 410 feet | 6 | Black guaranteed wrought-iron pipe, cut to exact length, with allowance for 1 tee in each run. | Main feed pipe. |
| 12 runs, 50 feet each | 6 | .....do | Do. |
| 1 run, 25 feet | 6 | .....do | Do. |
| 20 runs, 30 feet each | 2 | Galvanized wrought-steel pipe | Feed end east-and-west nozzle lines. |
| 20 pieces, 7 feet each | 2 | .....do | Nozzle-line risers. |
| 7 pieces, 15 feet each | 2 | .....do | Pipe under road, east-and-west lines. |
| 3,500 feet | 1½ | .....do | Do. |
| 3,500 feet | 1¼ | .....do | Do. |
| 3,200 feet | 1 | .....do | Do. |
| 1,800 feet | ¾ | .....do | Far end all nozzle lines. |
| 700 pieces, 9 feet each | 1¼ | Galvanized wrought-steel pipe, plain ends. | Pipe posts. |
| 7 | 6 by 2 by 2 | Black side outlet cast-iron tees | Main feed pipe. |
| 6 | 6 by 2 | Black cast-iron tees | Do. |
| 7 | 2 | Black malleable 90 ells | Bottom west risers. |
| 20 | 2 | Galvanized malleable 90 ells | Top east-and-west risers. |
| 20 | 2 | Galvanized long nipples | Feed end nozzle lines. |
| 20 | 2 by 1½ | Galvanized reducing sockets | Nozzle lines |
| 20 | 1½ by 1¼ | .....do | Do. |
| 20 | 1¼ by 1 | .....do | Do. |
| 20 | 1 by ¾ | .....do | Do. |
| 20 | 2 | Standard brass gate valves | Feed end nozzle lines. |
| 20 | ¾ | .....do | Far end nozzle lines. |
| 1 | 6 | Standard iron-body gate valve | End of main. |
| 20 | 2 | Trade name, etc., turning unions | Nozzle lines. |
| 3,160 | No. —. | Trade name, etc., nozzles | Do. |
| 700 | No. —. | Trade name, etc., galvanized hangers. | Top of posts. |

NOTE.—Main feed pipe is made 6-inch size full length, as full head of water is to be pumped to farther fields for surface irrigation.

## THE DESIGNING OF PUMPING PLANT.

As in the designing of the field system, the farmer should obtain all possible assistance in designing a suitable pumping equipment. It is desirable to purchase machinery for which repairs can be obtained readily from a local representative, yet when the services of an irrigation engineer are not obtainable the farmer should submit all possible data regarding the conditions the plant must fill to several reliable pump manufacturers for recommendations and quotations. A suitable request for the pump alone or a complete outfit including engine or motor for this purpose may be submitted in the following form:

GENTLEMEN:

You are requested to submit recommendations and bids on pumping equipment for spray irrigation purposes to fill the conditions outlined below. Prices should be quoted on (pump, engine, motor) delivered at ____________________ (nearest railroad station), accompanied by full descriptions of items it is proposed to furnish, stating guaranties, efficiencies, and making recommendations on the size and items of construction for suction and discharge pipes to be used.

The source of water supply is ---------- (well, creek, etc.).

The capacity of the water supply is ------ gallons per minute.

The foundations for pump and engine are to be of ---------- (concrete, brick, wood) set in ---------- (clay, loam, sand, rock) type of soil.

The vertical distance of water below proposed pump foundation is ------ feet.

The vertical distance water will draw down when pump is running is ------ feet.

The horizontal distance of water from proposed pump is ----------.

The vertical distance of proposed pump foundation from highest land to be irrigated is ----------.

The horizontal distance of proposed pump from the most distant irrigation unit is ----------.

The suction of pump must be ---------- (vertical or horizontal).

The discharge of pump must be ---------- (vertical or horizontal).

The number of bends in suction pipe must be ---------- of ---------- (90 or 45) degrees angle.

The number of bends in discharge pipe must be ---------- of ---------- (90 or 45) degrees.

The amount of water desired per minute is ----------.

The desired pressure on nozzles for the highest ground is ----------.

The height of nozzles above highest ground will be ----------.

The type of pump preferred is ---------- (displacement, centrifugal), to be connected to power by ---------- (belt, gear, direct).

The power desired for operating the pump is ----------.

I now have a ------ horsepower ---------- engine.

The speed of my engine is ------ revolutions per minute.

The size of engine belt pulley is ---------- diameter, ---------- width.

I can obtain alternating electric current of ---------- phase, ---------- cycles, ---------- voltage.

I can obtain direct electric current of ---------- voltage.

The following is a sketch of my water supply, showing the desired location of pumping plant and field to be irrigated.

## SUCTION LIFT.

It is advisable to set all pumps as close to the water as possible and under ordinary conditions the suction lift should not exceed that given in Table 5. Suction depends upon the atmospheric pressure, which decreases as altitude increases.

TABLE 5.—*Practical suction lift of pumps at different altitudes.*

| Altitude above sea level. | Practical suction lift of pumps.[1] | Altitude above sea level. | Practical suction lift of pumps.[1] |
|---|---|---|---|
| | *Feet.* | | *Feet.* |
| Sea level | 25 | 1 mile (5,280 feet) | 20 |
| ¼ mile (1,320 feet) | 24 | 1¼ miles (6,600 feet) | 19 |
| ½ mile (2,640 feet) | 23 | 1½ miles (7,920 feet) | 18 |
| ¾ mile (3,960 feet) | 21 | 2 miles (10,560 feet) | 17 |

---

[1] Practical suction lift of pumps is equal to the vertical distance water is lifted, plus the head due to friction.

## POWER.

The kind and amount of power a farmer should use for spray irrigation must depend much upon his local facilities for obtaining fuel or electricity. The fuels most commonly used in the humid regions are gasoline, kerosene, natural gas, and, in Florida, wood. In the arid regions the heavier oils, as well as electricity, are more available and can be added to the other common sources of power. With an engine a farmer is incurring no fuel charge except when it runs, although where a plant is to be run more or less continuously during an irrigation season, as in the arid districts, electricity is a much more automatic, cleaner, and often cheaper power to use. Some farmers may have a portable engine or tractor for other uses on the farm which can be used economically if the pump is purchased to suit such power.

TABLE 6.—*Horsepower required to lift different quantities of water to elevations of 10 feet to 300 feet.*

[Efficiency of pumping plant, 50 per cent of theoretical. Use for estimating purposes only.]

| Gallons per minute. | Elevation in feet. | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 125 | 150 | 175 | 200 | 250 | 300 |
| | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* | *h. p.* |
| 5 | 0.025 | 0.05 | 0.07 | 0.10 | 0.12 | 0.14 | 0.16 | 0.20 | 0.22 | 0.25 | 0.31 | 0.37 | 0.43 | 0.50 | 0.62 | 0.75 |
| 10 | .050 | .10 | .15 | .20 | .25 | .30 | .35 | .40 | .44 | .50 | .62 | .75 | .87 | 1.00 | 1.24 | 1.50 |
| 15 | .075 | .15 | .22 | .30 | .37 | .45 | .52 | .60 | .68 | .75 | .94 | 1.12 | 1.31 | 1.50 | 1.88 | 2.25 |
| 20 | .100 | .20 | .30 | .40 | .50 | .60 | .70 | .80 | .90 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.50 | 3.00 |
| 25 | .125 | .25 | .37 | .50 | .62 | .75 | .88 | 1.00 | 1.12 | 1.25 | 1.56 | 1.87 | 2.18 | 2.50 | 3.12 | 3.75 |
| 30 | .150 | .30 | .45 | .60 | .75 | .90 | 1.04 | 1.20 | 1.35 | 1.50 | 1.87 | 2.25 | 2.62 | 3.00 | 3.74 | 4.50 |
| 35 | .175 | .35 | .52 | .70 | .87 | 1.05 | 1.22 | 1.40 | 1.58 | 1.75 | 2.19 | 2.62 | 3.15 | 3.50 | 4.38 | 5.25 |
| 40 | .200 | .40 | .60 | .80 | 1.00 | 1.20 | 1.40 | 1.60 | 1.80 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 5.00 | 6.00 |
| 45 | .225 | .45 | .67 | .90 | 1.12 | 1.35 | 1.56 | 1.80 | 2.02 | 2.25 | 2.81 | 3.37 | 3.94 | 4.50 | 5.62 | 6.75 |
| 50 | .250 | .50 | .75 | 1.00 | 1.25 | 1.50 | 1.74 | 2.00 | 2.24 | 2.50 | 3.12 | 3.75 | 4.37 | 5.00 | 6.24 | 7.50 |
| 60 | .300 | .60 | .90 | 1.20 | 1.50 | 1.80 | 2.10 | 2.40 | 2.70 | 3.00 | 3.75 | 4.50 | 5.25 | 6.00 | 7.50 | 9.00 |
| 70 | .350 | .70 | 1.05 | 1.40 | 1.75 | 2.10 | 2.44 | 2.80 | 3.14 | 3.50 | 4.38 | 5.25 | 6.12 | 7.00 | 8.76 | 10.50 |
| 80 | .400 | .80 | 1.20 | 1.60 | 2.00 | 2.40 | 2.80 | 3.20 | 3.60 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 | 10.00 | 12.00 |
| 90 | .450 | .90 | 1.35 | 1.80 | 2.25 | 2.70 | 3.14 | 3.60 | 4.04 | 4.50 | 5.62 | 6.75 | 7.87 | 9.00 | 11.24 | 13.50 |
| 100 | .500 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 | 5.00 | 6.25 | 7.50 | 8.75 | 10.00 | 12.50 | 15.00 |
| 125 | .625 | 1.25 | 1.87 | 2.50 | 3.12 | 3.75 | 4.36 | 5.00 | 5.62 | 6.25 | 7.81 | 9.37 | 10.94 | 12.50 | 15.62 | 18.75 |
| 150 | .750 | 1.50 | 2.25 | 3.00 | 3.75 | 4.50 | 5.24 | 6.00 | 6.75 | 7.50 | 9.37 | 11.25 | 13.12 | 15.00 | 18.74 | 22.50 |
| 175 | .875 | 1.75 | 2.62 | 3.50 | 4.37 | 5.25 | 6.12 | 7.00 | 7.88 | 8.75 | 10.94 | 13.12 | 15.31 | 17.50 | 21.88 | 26.25 |
| 200 | 1.00 | 2.00 | 3.00 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 | 9.00 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | 25.00 | 30.00 |
| 250 | 1.25 | 2.50 | 3.75 | 5.00 | 6.25 | 7.50 | 8.75 | 10.00 | 11.25 | 12.50 | 15.62 | 18.75 | 21.87 | 25.00 | 31.24 | 37.50 |
| 300 | 1.50 | 3.00 | 4.50 | 6.00 | 7.50 | 9.00 | 10.50 | 12.00 | 13.50 | 15.00 | 18.75 | 22.50 | 26.25 | 30.00 | 37.50 | 45.00 |
| 350 | 1.75 | 3.50 | 5.25 | 7.00 | 8.75 | 10.50 | 12.25 | 14.00 | 15.75 | 17.50 | 21.87 | 26.25 | 30.62 | 35.00 | 43.74 | 52.50 |
| 400 | 2.00 | 4.00 | 6.10 | 8.00 | 10.00 | 12.00 | 14.00 | 16.00 | 18.00 | 20.00 | 25.00 | 30.00 | 35.00 | 40.00 | 50.00 | 60.00 |
| 450 | 2.25 | 4.50 | 6.75 | 9.00 | 11.25 | 13.50 | 15.75 | 18.00 | 20.25 | 22.50 | 28.13 | 33.75 | 39.37 | 45.00 | 56.26 | 67.50 |
| 500 | 2.50 | 5.00 | 7.50 | 10.00 | 12.50 | 15.00 | 17.50 | 20.00 | 22.50 | 25.00 | 31.25 | 37.50 | 43.75 | 50.00 | 62.50 | 75.00 |
| 600 | 3.00 | 6.00 | 9.00 | 12.00 | 15.00 | 18.00 | 21.00 | 24.00 | 27.00 | 30.00 | 37.50 | 45.00 | 52.50 | 60.00 | 75.00 | 90.00 |
| 700 | 3.50 | 7.00 | 10.50 | 14.00 | 17.50 | 21.00 | 24.50 | 28.00 | 31.50 | 35.00 | 43.75 | 52.50 | 61.25 | 70.00 | 87.50 | 105.00 |
| 800 | 4.00 | 8.00 | 12.00 | 16.00 | 20.00 | 24.00 | 28.00 | 32.00 | 36.00 | 40.00 | 50.00 | 60.00 | 70.00 | 80.00 | 100.00 | 120.00 |
| 900 | 4.50 | 9.00 | 13.50 | 18.00 | 22.50 | 27.00 | 31.50 | 36.00 | 40.50 | 45.00 | 56.25 | 67.50 | 78.75 | 90.00 | 112.50 | 135.00 |
| 1,000 | 5.00 | 10.00 | 15.00 | 20.00 | 25.00 | 30.00 | 35.00 | 40.00 | 45.00 | 50.00 | 62.50 | 75.00 | 87.50 | 100.00 | 125.00 | 150.00 |

Table 6 gives the power necessary to lift different quantities of water different heights. The table is based on an efficiency of 50 per cent of the theoretical horsepower, and will serve the farmer for general estimating purposes. Small plants under 100 gallons per minute, especially in the case of centrifugal pumps, are apt to require a greater horsepower than given, while the larger plants should require somewhat less, due to the greater efficiencies. In every case, however, the actual horsepower to use should be determined by the manufacturers furnishing the pump.

## OUTLINE OF PROCEDURE FOR INSTALLING SPRAY IRRIGATION SYSTEMS.

This outline is for the installation of an overhead spray plant, but by substituting underground laterals and nozzle risers for nozzle lines and posts it will apply to the stationary, circular nozzle type of system.

First, excavate a trench for the main feed pipe. Second, lay the main feed pipe. Third, screw nozzle line risers into main feed pipe. Fourth, install posts for nozzle lines. Fifth, assemble and tap nozzle lines for nozzles. Sixth, install pumping equipment and house. Seventh, pump water thorugh distribution system to flush out dirt. Eighth, install nozzles in nozzle lines.

### INSTALLING THE MAIN FEED PIPE.

The main feed pipes are expensive items and therefore should be carefully designed and located. Usually the main pipes should be made as short as possible and yet intersect the nozzle lines at intervals so that their length will not exceed 600 feet; otherwise the sizes of the nozzle lines become large enough to offset any saving in cost from the use of fewer mains. The field to be irrigated should be divided into irrigation units, each unit having an area to correspond to the capacity of the main and pumping plant. The main feed pipe should be given sufficient size to carry the water for one unit at a time without excessive friction loss. (See Table 2, p. 30.) When the most distant unit is reached the main can be decreased in size gradually to correspond to the amount of water taken out by each nozzle line, unless the full capacity is needed for extension or another type of irrigation in an adjoining field. All pipe over 2 inches in diameter should be cut in the shop to fit the spacing of nozzle lines. Straight mains of the larger sizes should be equipped with expansion joints near the pumps to absorb the contraction and expansion of the pipe due to changes of temperature. Easy bends should be used where it is necessary to change the course of the main. All angles retard the flow of water by friction.

The main feed pipe should be laid underground below the depth of cultivation and on a grade so it can be drained at convenient places, especially in regions where freezing occurs. The main should be installed as the first part of the construction so that the posts for the nozzle lines can be set to correspond with the risers from the main.

Excavating for the main can be facilitated by plowing and throwing the loose materials out by hand. The second and following plowings should be done with a narrow plow hitched to a steady horse. The main pipe should be put together while lying on timbers across the trench, so that each joint can be fitted easily and tightened. Usually a section of 200 feet or more can be put together and then allowed to sag gradually into the trench as the length increases. There are two points where installation of a main feed pipe may begin. If the pumping plant has been installed and careful measurement has been made to the first lateral, the main can begin at the pump. If there is an important branching of mains, then the starting point can be at the branch or the first definitely located nozzle line nearest the pump and the pipe then laid in two directions toward the pump and through the field. The main pipe then can be cut to fit to the pump or the pump set to fit the main with the aid of the expansion joint and flange couplings.

### INSTALLING NOZZLE LINES.

The first parts of the field system to be installed are the posts. These should be located carefully to line up in every direction, so far as possible, like trees in an orchard. The risers from the main feed pipe should form the first post to each line and form a starting point for measuring. It usually is advisable to locate the posts on the two outside lines of the field and then one center line in which the posts will line up with the outside ones. It is an easy matter then to locate the remainder of the posts by intersection sighting. In the case of wooden posts, the tops should be cut to uniform heights. Posts made from pipe can be driven a short distance into the earth in the bottom of a post-auger hole, and after they are lined up and adjusted to a uniform height the auger hole about the pipe can be filled with concrete.

After the posts have been set in the field the bearings are fastened to them and the sections of pipe placed on the ground along the side of each line. Each nozzle line is then screwed together tightly, great care being taken to remove all dirt and filings from each section. Paint or lead should not be used on the inside of the joints, as such material on the inside would cause clogging of the nozzles. It is better to apply heavy graphite grease after the thread has been started. When wooden posts are used, the pipe line is laid upon 60 to 90 penny spikes, one of which is driven firmly into the side of each post. The spikes should be placed about 3¾ feet to 4 feet above the ground, depending upon the height of the man who will do the drilling for the nozzles. Where pipe posts are used, the pipe can be held in place for drilling by wrapping a tight wire twice around the posts, then looping the wire around the nozzle pipe line so that the pipe will hang several inches below where it is attached to posts. The pipe is then fastened rigidly so that it can not turn while being drilled. A good way to do this is to replace the handle in the turning union with a 10 or 12 foot length of ¾-inch pipe, so that one end will rest on the ground, acting as a wrench holding the entire line. The nozzle holes are then spaced with a stick cut the proper length and marked with crayon. Three to four feet is the usual distance between the nozzles.

The nozzle holes must be in a straight line along the shell of the pipe. To accomplish this a special drilling machine is used. This machine hangs on the pipe and can be set in a perpendicular position by means of an attached level bubble. It is securely clamped for each drilling and the hole is made on the lower side of the pipe. The shank of the drill is a thread tap, so that the hole is threaded by running the drill into the pipe at the completion of the hole. Lard oil only should be used on the drill, as mineral oils cause the metals to heat and pinch the drill. A drop or two of oil placed on the upper side of the pipe will run to the lower side and be sufficient for each hole.

When the drilling of a line is complete the pipe is placed in its permanent supports and connected to the feed pipe. It always is desirable to run the water through the lines before screwing in the nozzles. This will wash out all the foreign materials in the pipe, and the nozzles can be put in at any time. When the water is first pumped through after the nozzles are in place, the end of the pipe should be left open for a time and each nozzle inspected. Scales or dirt in a nozzle can be dislodged by striking the opposite side of the pipe a sharp blow with a hammer while a finger is placed over the nozzle. A small wire thrust into the nozzle and quickly withdrawn also assists in removing obstructions.

## COST DATA.

Cost data for material can be given only for general estimating purposes, as the markets fluctuate and the prices must vary also with the freight to different points.

Manufacturers have a standard list of prices on pipe and fittings from which discounts are given, according to the condition of the metal market, freight rates, and size of order. The standard lists are given in Table 7, with the probable range of discounts based on Pittsburgh, Pa.

**TABLE 7.**—*Standard list prices on wrought-iron and steel pipe, black and galvanized.*

| Diameter in inches. | List price per foot. | Weight per foot, threads and couplings. | Threads per inch. | Diameter in inches. | List price per foot. | Weight per foot, threads and couplings. | Threads per inch. |
|---|---|---|---|---|---|---|---|
| ¾ | $0.11½ | 1.134 | 14 | 3½ | $0.92 | 9.202 | 8 |
| 1 | .17 | 1.684 | 11½ | 4 | 1.09 | 10.889 | 8 |
| 1¼ | .23 | 2.281 | 11½ | 5 | 1.48 | 14.810 | 8 |
| 1½ | .27½ | 2.731 | 11½ | 6 | 1.92 | 19.185 | 8 |
| 2 | .37 | 3.678 | 11½ | 7 | 2.38 | 23.769 | 8 |
| 2½ | .58½ | 5.819 | 8 | 8 | 2.50 | 25.000 | 8 |
| 3 | .76½ | 7.616 | 8 | | | | |

APPROXIMATE RANGE OF DISCOUNTS.

| | Per cent off list. |
|---|---|
| Black wrought-iron pipe, random lengths | 65 to 75 |
| Galvanized wrought-iron pipe, random lengths | 55 to 65 |
| Black wrought-steel pipe, random lengths | 70 to 80 |
| Galvanized wrought-steel pipe, random lengths | 65 to 75 |
| Cast-iron and malleable fittings | 65 to 75 |

**TABLE 8.**—*Standard list prices on black fittings for wrought iron and steel pipe.*

| | Diameter of pipe (inches). | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ¾ | 1 | 1¼ | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 6 | 7 | 8 |
| Ells, R. H | 0.08 | 0.10½ | 0.16 | 0.20 | 0.28 | 0.50 | 0.75 | 1.05 | 1.20 | 1.75 | 2.00 | 2.75 | 4.70 | 6.75 |
| Ells, reducing and R. & L | .09 | .12 | .18 | .23 | .32 | .60 | .85 | 1.20 | 1.40 | 2.00 | 2.30 | 3.15 | 5.40 | 7.75 |
| Ells, 45° | .10 | .12 | .19 | .24 | .34 | .60 | .90 | 1.25 | 1.45 | 2.20 | 2.50 | 3.45 | 5.90 | 8.50 |
| Ells, side outlet | .21 | .30 | .48 | .60 | .84 | 1.50 | 2.2 | 3.15 | 3.60 | 5.25 | 6.00 | 8.25 | ..... | ..... |
| Tees | .12 | .15 | .23 | .29 | .41 | .73 | 1.15 | 1.50 | 1.75 | 2.55 | 3.00 | 4.00 | 6.80 | 9.75 |
| Tees, reducing | .14 | .17 | .27 | .33 | .47 | .83 | 1.25 | 1.75 | 2.00 | 2.95 | 3.50 | 4.60 | 7.80 | 11.25 |
| Crosses | .22 | .27 | .42 | .53 | .75 | 1.30 | 2.00 | 2.70 | 3.15 | 4.60 | 5.50 | 7.25 | 12.25 | 17.50 |
| Caps | .08 | .11 | .15 | .22 | .26 | .40 | .54 | .75 | .87 | 1.05 | 1.20 | 1.55 | 2.50 | 2.85 |
| Sockets, reducing | .12 | .18 | .25 | .36 | .43 | .60 | .80 | 1.00 | 1.35 | 1.85 | 2.00 | 2.70 | 5.35 | 6.75 |
| Bushings | .05 | .06 | .07 | .09 | .14 | .21 | .30 | .40 | .50 | .75 | .93 | 1.25 | 1.87 | 2.75 |
| Plugs | .03 | .04 | .05 | .07 | .10 | .18 | .25 | .38 | .42 | .65 | .88 | 1.20 | 1.85 | 2.75 |

GALVANIZED FITTINGS FOR WROUGHT IRON AND STEEL PIPE.

| | ¾ | 1 | 1¼ | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ells, R. H | 0.16 | 0.21 | 0.32 | 0.40 | 0.56 | 1.00 | 1.50 | 2.10 | 2.40 | 3.50 | 4.00 | 5.50 | 9.40 | 13.50 |
| Ells, reducing | .18 | .24 | .36 | .46 | .641 | .20 | 1.70 | 2.40 | 2.80 | 4.00 | 4.60 | 6.30 | 10.80 | 15.50 |
| Ells, 45° | .20 | .24 | .38 | .48 | .68 | 1.20 | 1.80 | 2.50 | 2.90 | 4.40 | 5.00 | 6.90 | 11.80 | 17.00 |
| Tees | .24 | .30 | .46 | .58 | .82 | 1.46 | 2.20 | 3.00 | 3.50 | 5.10 | 6.00 | 8.00 | 13.60 | 19.50 |
| Tees, reducing | .28 | .34 | .54 | .66 | .94 | 1.66 | 2.50 | 3.50 | 4.00 | 5.90 | 7.00 | 9.20 | 15.60 | 22.50 |
| Crosses | .44 | .54 | .84 | 1.06 | 1.50 | 2.60 | 4.00 | 5.40 | 6.30 | 9.20 | 11.00 | 14.50 | 24.50 | 35.00 |
| Sockets, red | .16 | .25 | .35 | .45 | .86 | 1.20 | 1.60 | 2.00 | 2.70 | 3.70 | 4.00 | 5.40 | 10.70 | 13.50 |
| Bushings | .10 | .12 | .14 | .18 | .28 | .42 | .60 | .80 | 1.00 | 1.50 | 1.85 | 2.50 | 3.75 | 5.50 |
| Plugs | .06 | .08 | .10 | .14 | .20 | .36 | .50 | .76 | .84 | 1.30 | 1.75 | 2.40 | 3.70 | 5.50 |

AVERAGE COST OF STANDARD BRASS SCREW GATE VALVES.

| | | | |
|---|---|---|---|
| ¾ inch | $0.60 | 1 inch | $0.85 |
| 1¼-inch | 1.10 | 1½-inch | 1.50 |
| 2-inch | 2.25 | | |

AVERAGE COST OF STANDARD IRON BODY SCREW GATE VALVES.

| | | | |
|---|---|---|---|
| 2½-inch | $2.85 | 5-inch | $7.00 |
| 3-inch | 3.50 | 6-inch | 8.00 |
| 3½-inch | 4.25 | 7-inch | 12.25 |
| 4-inch | 5.25 | 8-inch | 13.50 |

The smaller the pump the greater the cost per gallon capacity. Small displacement pumps of 10 to 50 gallons per minute capacity range in cost from $4 to $1 per gallon per minute capacity. Pumps having capacities of 50 to 100 gallons per minute range in cost from $3 to $1 per gallon per minute capacity. Larger pumps of the duplex and triplex types range as low as $1 per gallon per minute capacity. These cost figures are for surface displacement pumps and do not apply to deep-well equipment, which must vary according to local requirements.

The cost of centrifugal pumps is less than that of displacement pumps having the same capacity, but the same general rule holds that the smaller the pump the greater the cost per unit capacity. It seldom is feasible to use a centrifugal pump for spray irrigation where the requirement is less than 125 gallons per minute. The cost can be assumed to range from $1.25 per gallon per minute capacity for the small pumps to 10 cents per gallon per minute capacity for large pumps. The figures are for horizontal high-pressure centrifugal pumps for belt or direct drive and do not apply to vertical-shaft or deep-well turbine pumps, the cost of which varies according to local requirements.

Pumps are made in definite sizes, each size having an economic capacity. The irrigation system should be designed to fit some standard-sized pump, so far as possible, in order to make the most economical installation in first cost and in operation.

TABLE 9.—*Range in prices per horsepower for electric motors.*

| Horsepower. | Alternating current. | | Direct current. | |
|---|---|---|---|---|
| | High speed per horsepower. | Low speed per horsepower. | High speed per horsepower. | Low speed per horsepower. |
| 1 | $41 | $81 | $48 | $54 |
| 5 | 14 | 35 | 23 | 26 |
| 10 | 14 | 27 | 20 | 23 |
| 30 | 12 | 20 | 15 | 16 |
| 25 | 11 | 20 | 13 | 16 |
| 35 | 9 | 18 | .......... | .......... |

The cost of gas and oil engines varies according to type, materials of construction, surface finish, ignition system, fuel equipment, etc. In the case of engines built for gas and the lighter oils, like gasoline, kerosene, etc., the four-cycle engines usually are much heavier than the two-cycle, and their cost ranges somewhat in proportion. Four-cycle engines of this type may be estimated at a cost of $25 to $40 per horsepower, while two-cycle engines range from $18 to $25 per horsepower. Heavy oil engines are built in greater weight, regardless of cycle, and their cost should be estimated from $40 to $50 per horsepower.

For estimating purposes electric motors may be divided into two general classes, those running on alternating current and those running on direct current. The chief factor affecting the price of a given motor is the speed for which it is built—the lower the speed the higher the price. Table 9 gives the range in price per horsepower for simple types of motors adaptable to ordinary pumping conditions. The prices do not include cast-iron sliding bases, pulleys, wiring, etc.

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# INVESTIGATIONS OF THE ROTTING OF SLASH IN ARKANSAS.[1]

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## INTRODUCTION.

Two very important factors must be considered in administering timber-sale areas, viz, the conservation of the present second growth and the leaving of the area in the best possible condition for future reproduction. The particular method of brush disposal over such areas is therefore of importance from the reproduction viewpoint. In the semiarid regions of the Southwest the dominant factor governing reproduction is the obtaining and conserving of sufficient moisture to germinate the seeds and to carry the seedlings over the first four or five years of their existence. In the forests of Arkansas the conservation of the moisture is of minor importance, since the annual rainfall is usually sufficient to supply all of the moisture necessary for the germination of the seed and for the continued growth of the seedlings.

Fire is a very important factor from a reproduction viewpoint in the National Forests of Arkansas. The Ozark National Forest consists almost exclusively of mixed stands of timber in which hardwood trees usually predominate, while the Arkansas National Forest is dominated by pines. The annual leaf fall from the deciduous trees accumulating year after year on the ground and the large growth of underbrush present constitute a perpetual fire menace. Even on areas in these two forests where shortleaf pine (*Pinus echinata*)[1] is being logged there are usually enough deciduous trees and underbrush present to make a ground litter from the fallen leaves, to which must be added the usual leaf litter found under pine trees.

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[1] The writer is under obligations to Mrs. Flora W. Patterson and Drs. E. A. Burt, C. L. Shear, and W. A. Murrill for assistance rendered in identifying many of the fungi mentioned in this bulletin.

The method of brush disposal that will give to the reproduction over these areas protection from fire and yet leave as much as possible of the forest litter, leaves, twigs, etc., on the ground to rot, thereby adding fertility to the soil and protecting it against excessive erosion by restraining the run-off, is the one that should be adopted. The best method of brush disposal when the slash remains on logged areas is that which leaves the brush in such a condition that it will rot most rapidly, thus removing as soon as possible the fire menace from this source.

## METHODS OF BRUSH DISPOSAL.

The three methods of brush disposal discussed in this bulletin are (1) pulling, (2) piling, and (3) scattering.

By "pulling" is meant that the brush in the tops of the felled trees is not lopped, but is left exactly as the tree tops fall except when they fall on or near reproduction. When brush is too close to reproduction it is pulled away from the young trees and merchantable timber, to decrease the danger from possible fire; hence the term "pulled brush."

The terms "piling" and "scattering" are self-explanatory.

Piling is the usual method of brush disposal followed in the National Forests of Arkansas. However, a few Forest Service areas were examined where the brush had been scattered as an experiment. In this State pulling the brush has not yet been practiced on Government sales, but on alienated or patented lands all of the brush in the tops of the felled trees is generally left as it falls. This is really a combination of "pulling" and "scattering," since the tops are left unlopped while the branches cut from the merchantable portion of the bole are scattered on the ground. The character and rate of rotting of the brush left on these private areas will therefore be the same as when the brush is pulled or scattered.

This bulletin deals specifically with the rapidity with which the brush rots and with the fungi causing this rotting under each of these methods. It will be necessary in discussing the various methods of brush disposal to take into consideration the types of timber being cut. In the Ozark National Forest the main timber is white oak (*Quercus alba*) intermixed with black oak (*Q. velutina*), post oak, (*Q. stellata*), and several other species of minor importance, while on certain areas some shortleaf pine is found. In the Arkansas National Forest the bulk of the timber to be logged is shortleaf pine.

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[1] The nomenclature for trees used in this paper is that of George B. Sudworth. (Check list of the forest trees of the United States, their names and ranges. U. S. Dept. Ag. Div. Forestry Bul. 17, 144 p. 1898.)

The investigations of the rotting of slash in Arkansas were carried on in the Arkansas and Ozark National Forests on areas which had been logged from 1 to 10 years. All of the areas examined which had been logged for more than five years were on private or patented lands, but located within these National Forests. The conclusions reached from these studies should be applicable to all of the other areas in these two forests, since the underlying principles are identical and the climatic conditions very similar.

## WHITE-OAK SLASH.

### FUNGI WHICH ROT THE SLASH.

Four main fungi were found rotting the white-oak slash, viz, *Stereum rameale*, *S. versiforme*, *S. umbrinum*, and *S. fasciatum*. All are sap-rotting fungi which cause but little apparent change in the texture of the wood. They produce what might be called indeterminate rots, since there are no well-defined characteristics which mark any one of them. All slightly discolor the wood, which later becomes whitish in color, lighter in weight, and easily broken. Strange to say, each of these fungi rots its own special portion of the slash. *Stereum rameale* is usually found attacking twigs which bear the leaves and very small branches (1 inch or less in diameter). This fungus seems to begin on the twigs and works gradually down them to where the branches are about 1 inch in diameter; there two other fungi (*S. versiforme* and *S. umbrinum*) take up the work and rot the small branches up to 2 or 3 inches in diameter, where a fourth fungus (*S. fasciatum*) usually begins its attack on the wood. This is the main fungus which rots the sapwood of the logs and large branches 3 inches or more in diameter, and it is often found rotting the sapwood of the stumps as well as the boles and large branches of standing dead oak trees. None of these fungi destroys the attacked wood completely, its final disintegration being left to other groups of fungi, insects, etc.

The heartwood of the large branches and trunks remains for many years after the sapwood is destroyed, but meantime it is being slowly rotted by a delignifying fungus (*Stereum frustulosum*), which produces small cavities or pockets in the wood.

Other fungi of minor importance were found attacking the oak slash, the most important of which was a small, dark-brown, gelatinous fungus (*Exidia glandulosa*) found at irregular intervals along the twigs and small branches. Its action on the wood is to produce whitish rotten areas, usually extending entirely through the branch, thus forming a line of weakness which ultimately causes the branch to break into small sections (2 to several inches long). These pieces fall to the ground, where complete disintegration follows.

*Merulius corium*, *Hymenochaete curtisii*, *Diatrype stigma*, and *Stereum hirsutum* are other fungi occasionally found attacking the twigs and small branches, while *Merulius tremellosus*, *Polystictus pergamenus*, *P. versicolor*, *Polyporus gilvus*, *P. cinnabarinus*, *P. benzoinus*, *Lenzites betulina*, *Flammula* sp., *Panus stipticus*, *Stereum spadiceum*, *Lycoperdon pyriforme*, *Xylaria hypoxylon*, and several species of Poria are occasionally found rotting logs, stumps, and large branches.

*Panus stipticus*, *Flammula* sp., *Merulius tremellosus*, *Xylaria hypoxylon*, and *Lycoperdon pyriforme* are fungi which apparently attack wood which has been more or less rotted by other fungi.

*Polystictus pergamenus*, *P. versicolor*, *Polyporus gilvus*, *P. cinnabarinus*, *P. benzoinus*, and *Lenzites betulina* rot both the sapwood and heartwood, but unfortunately none of them are common on oak slash in the forests of Arkansas. None of the fungi found rotting the oak slash produces a heart rot in the living tree. However, certain fungi which cause heart rots in living oak trees will continue to grow in the infected wood after the trees are felled. The most important of these are *Hydnum erinaceus*, *Polyporus pilotae*, *P. sulphureus*, and *Stereum subpileatum*.

### BRUSH WHEN PULLED.

Soon after a living tree is felled, wood-boring insects and various fungi begin their work of disintegration and decay. The first evidence of fungous activity in slash is a discoloration of the sapwood in the twigs, branches, and trunks, which usually begins a few months after the trees are felled. Marked evidences of decay in the shape of well-defined rotten spots and areas in the wood and the formation of fruiting bodies or sporophores of the wood-rotting fungi do not appear until one or two years after the trees are felled.

All of the leaves in the tops of felled oak trees will usually fall in from one to three years, depending more or less upon the age of the leaves at the time the oak was cut and to a slight extent on the locality in which the timber is situated.

The small branches and twigs gradually rot, and the majority of them will have fallen to the ground at the end of four years. By the end of six years practically all of the branches in the tops will have rotted and fallen except some of the very large ones which have much heartwood. Also, practically all of the sapwood in the boles and cull logs will have rotted away during this time.

### BRUSH WHEN PILED.

White-oak brush piles were examined, ranging from 1 to 5 years in age. During the first year after the trees were cut but little evidence of rot could be seen except a discoloration of the sapwood. By the end of the second or third year all of the leaves had fallen from the twigs which were exposed to the sun's rays, and the brush at the tops and sides of the piles where exposed to the sunlight had rotted to some extent, while the slash in the middle of the piles not in actual contact with the ground and yet protected from the sunlight was rotted but slightly, if at all. The twigs and small branches at the bottoms of the piles were more or less rotted by certain other fungi (called "ground" fungi in this bulletin), which apparently entered these branches from the soil. These ground fungi seem to rot the brush more rapidly and more thoroughly than the regular slash-rotting fungi.

Usually there is but little evidence of rot in the center of the piles during the first four years after piling. However, around the edges and through crevices in the top the sunlight sometimes penetrates sufficiently to permit slight fungous growth. Nevertheless, there is a marked difference between the rotting of the brush in the center of the piles not adjacent to the ground and that at the top and bottom of the pile.

By the end of five years the top and bottom of the piles have rotted to a considerable extent, while the brush in the center of the piles, where it had become more or less exposed to the sun's rays, was beginning to rot.

For the brush in the center of the piles to rot completely it apparently (1) must be brought within range of the soil moisture by the rotting of the brush below it and by the settling of the pile, or (2) the upper portion must disintegrate sufficiently for the sun's rays to reach the center of the pile. Undoubtedly, both conditions finally develop and aid in the rotting of the brush which was originally in the center of the piles.

In a white-oak brush pile the layer of brush at the bottom would be the only one even in partial contact with the soil, while the remainder of the pile would be held from the soil by this first layer and therefore could not receive any benefit from the soil moisture. Neither are the piles dense or compact enough to raise the moisture content of the air around the brush in the piles sufficiently to encourage the growth of the ground fungi in branches not in actual contact with the soil. On the other hand, the brush not in contact with the soil in the piles and yet sheltered from sunlight is deprived of the activity of the fungi which normally rot slash in the open; that is, slash when left as it falls in the tree tops.

Since piles more than five years old were not found, the writer can not state positively the length of time necessary for a medium-sized compact brush pile of white oak to rot completely. Apparently it would take from three to six years longer than if the brush were either pulled or scattered. However, if the piles are very small, the brush will rot with about the same rapidity as when the tops are left unlopped, since the sunlight can then penetrate to the bottom.

### SPOROPHORE DEVELOPMENT ON PILED BRUSH.

The difference between the development of sporophores at the top, middle, and bottom of brush piles is very marked. Practically every twig and limb at the top of the pile bore the characteristic sporophores of *Stereum rameale*, *S. umbrinum*, and *S. versiforme* on the rotting limbs, while no sporophores whatever were found on branches in the center of brush piles which were large and compact enough to exclude the sunlight. Very rarely were any sporophores of wood-rotting fungi found on the material at the bottom of the piles, although sterile mycelium was frequently present on the brush so situated. It was therefore difficult to determine what fungi were concerned in the rotting of the brush in the bottom of the piles. However, sporophores were found of *Merulius tremellosus*, *Peniphora flavido-alba*, *Odontia* sp., *Poria pulchella*, and two unidentified species of Poria.

### BRUSH WHEN SCATTERED.

When the brush is lopped and scattered it rots much more quickly than when piled, and in some localities somewhat more quickly than when left attached to the tops. On the areas examined the gain in the rotting of brush when scattered compared to that when pulled was usually about one year.

When white-oak brush is scattered, only small portions of the limbs are actually in contact with the soil. The same fungi, therefore, that rot the unlopped brush will also rot most of the scattered brush, and with about the same rapidity.

Brush lying on the ground sometimes absorbs from the soil sufficient moisture for the growth of ground fungi in those portions of the limbs which are in actual contact with the soil. On many of the areas examined the additional moisture obtained from the soil by the scattered brush was not sufficient to cause the ground fungi to attack the prostrate limbs.

The influence of soil moisture on the branches lying on the ground usually does not extend more than 4 to 6 inches from the point where the limb is in contact with the soil. This means that the benefit to be derived from the ground fungi rotting a branch is limited to that portion directly in contact with the soil. On account of the small quantity of the brush thus situated, little of it is attacked by the ground fungi, and the benefits thereby derived are correspondingly slight.

At the end of five to six years all of the brush (twigs and small branches) which was scattered will have rotted, and much of it will have disappeared. It was also no uncommon thing to find partially rotted brush, whether piled, scattered, or lopped, attacked by white ants (termites) and the partially rotted wood replaced to some extent by dirt.

### BLACK-OAK AND POST-OAK SLASH.

Black-oak and post-oak slash was attacked by practically the same fungi which rot the white oak; however, but little of this type of slash was seen. The twigs and small branches of the black oak in most of the cases examined seemed to rot somewhat more slowly than white-oak slash of the same character, while the post-oak slash seemed to rot with about the same rapidity as the white oak.

*Polyporus cinnabarinus* was occasionally found rotting the large limbs and boles of the black oak, while the small twigs and limbs of the post-oak slash were sometimes attacked by *Schizophyllum commune*, and cull logs and stumps were occasionally attacked by *Lentinus lecomtei*. *Stereum ochraceo-flavum* was the principal fungus found rotting fire-killed oak bushes 2 inches or less in diameter, while *Polystictus pergamenus* was the fungus usually found attacking fire-killed trees and fire-killed areas on standing living trees of all species of oak.

### SHORTLEAF-PINE SLASH.

Shortleaf-pine slash was examined on areas which had been logged from two to nine years.

#### FUNGI WHICH ROT THE SLASH.

Two main fungi were found rotting the shortleaf-pine slash. One begins work in the ends of the small branches and works downward toward the trunk. This is usually *Lenzites sepiaria*, a dry-rot organism prevalent throughout the United States. This fungus has never been found by the writer attacking slash which was not exposed to the direct rays of the sun.

The second fungus enters the cull logs, boles of the tree tops, and branches 2 inches or more in diameter. It is what the writer previously has called the "white-fir fungus" (*Polystictus abietinus*).[1] It is a sap-rotting organism and usually rots but little, if any, of the heartwood.

---

[1] Long, W. H. A new aspect of brush disposal in Arizona and New Mexico. *In* Proc. Soc. Amer. Foresters, v. 10, no. 4, p. 383–398. 1915.

At the bottom of brush piles a fungus which has been identified as *Polyporus amorphus* was rather common. It apparently does not attack branches and limbs which are not in contact with the soil.

*Merulius ambiguus* was occasionally found on small branches, while *Fomes annosus*, *Poria subacida*, and *P. vaporaria* were found on large prostrate limbs, trunks, and stumps. *Polyporus palustris*, *Fomes annosus*, and *Corticium galactinum* seem to be the principal fungi rotting the pine stumps.

### BRUSH WHEN PULLED.

All of the needles in the tops of felled shortleaf-pine trees will fall in from one to three years, depending somewhat on the locality in which the timber is located. The branches will gradually rot, and many of them will have fallen from the trunk at the end of three to four years. By the end of five years practically all of the branches, large and small, in the tops will have rotted and fallen to the ground. Also, most of the sapwood in the boles and cull logs will have rotted in this time.

Pitchy limbs and trunks containing much resin rot very slowly and may be found long after the less resinous wood has disappeared.

*Polystictus abietinus* and *Lenzites sepiaria* seem to rot branches which are 8 to 10 feet from the ground just as rapidly as those near the ground. *Lenzites sepiaria* also attacks decorticated logs and the exposed portions of railroad ties after they are laid in the track.

### BRUSH WHEN PILED.

Shortleaf-pine brush piles were examined, ranging from 1 to 5 years in age. It was found that during the first year after the tree was cut but little rotting occurred, even in the small branches. By the end of the second or third year practically all of the needles had fallen from the limbs which were exposed to the sun's rays, while the needles in the middle of the piles, which were protected by the overlying brush, were in good condition and still attached to the limbs. In five years, brush at the top of the piles had practically rotted as far as the fungi which were attacking them could rot it, while the brush in the middle of the piles showed few signs, if any, of rotting. In the bottom of the piles the brush was well rotted, but by fungi different from those rotting the brush at the top of the piles. In other words, a brush pile of shortleaf pine will be rotted at the top by *Lenzites sepiaria* and *Polystictus abietinus*, the center of the pile will be rotted but little, while the brush at the bottom of the pile in contact with the soil will be rotted by certain ground fungi, one of which has been identified as *Polyporus amorphus*. This means that before the center of the brush piles will rot, both the top and bottom of the piles must disintegrate sufficiently to expose the center of the pile either to the sunlight or to the moisture of the soil. This would probably add from three to five years at least to the length of time it would take to rot the slash in the brush pile as compared to that required if pulled or scattered.

### BRUSH WHEN SCATTERED.

Practically the same conditions hold for shortleaf-pine slash when lopped and scattered as for oak slash; that is, the same groups of fungi which attack the pulled pine slash will attack the slash when scattered on the ground unless it be covered with leaf débris. Ground fungi will also attack that portion of the brush immediately in contact with the soil, provided the area under consideration is not too dry, like the south and southeast slopes of steep hillsides. In such locations no evidence was found of ground fungi attacking the scattered brush, or even the brush in the bottom of the piles. This means that the pine brush when lopped and scattered will rot much quicker than when it is piled, and on some sites slightly quicker than when left attached to the tops or pulled.

## THE GROWTH OF WOOD-ROTTING FUNGI.

There is this physical factor to be kept in mind when considering the rotting of slash, viz, that the quantity of water which a limb or branch obtains is practically limited to the precipitation which that limb or branch receives and is able to absorb through its bark into the sapwood and that, so far as the amount of moisture in the wood itself is concerned, the humidity of the air around the branch would not be an important factor, since conditions would have to be very unique which would enable a branch covered with bark to absorb from the surrounding air a sufficient quantity of water to make any appreciable difference in the water content of the branch or limb. This would mean that the distance the branch was from the ground, whether 1 foot or 5 feet, would make but little difference in the relative supply of moisture obtainable from the atmosphere which the wood-rotting fungi in the branch could utilize. It might, however, determine to a slight extent the amount of moisture which the limbs could lose, especially in the bottoms of the piles. In regions of heavy dews the brush lying within 1 or 2 feet of the ground might obtain more moisture than brush farther from the ground.

This indicates that the slash would have to be practically in contact with the soil to gain any appreciable quantity of moisture other than that obtained from precipitation, and from the very nature of the oak brush only small portions of any given limb would be thus placed.

Different groups of fungi seem to have adapted themselves to certain growth conditions. For instance, *Stereum rameale* and *S. hirsutum* were usually found only on the twigs and small branches, while *S. umbrinum* and *S. versiforme* occurred mainly on twigs and branches 2 inches or less in diameter. None of these four fungi were found attacking large limbs and trunks of the felled trees, while *S. fasciatum*, very common on stumps and trunks, rarely occurred on branches less than 3 inches in diameter. None of them were found growing on timber which was entirely shaded from the sun.

The fungi which rot that portion of the branches lying in actual contact with the ground under the brush piles belong to an entirely different group. Such fungi apparently need a large supply of moisture and probably enter the wood from mycelia already growing and ramifying in the leaf débris in the soil. This group of fungi includes those which are normally found attacking wood partially or entirely buried in the soil, such as stumps and posts.

## WHY BRUSH IN THE CENTER OF THE PILE DOES NOT ROT.

Why the fungi which are found attacking the limbs exposed to the sunlight will not usually attack the brush in the center or bottom of the piles when protected from the sun's rays is not known. Apparently temperature and moisture are not the only prominent factors controlling fungous growth and activity in nature. Is it possible that sunlight is a factor in the germination and growth of wood-rotting fungi in their natural habitats?

In a previous article by the writer,[1] the theory was advanced that the reason why the brush in the center and bottoms of the piles in the semiarid regions of Arizona and New Mexico did not rot was due to temperature conditions prevailing in the high altitudes. That the temperature in Arkansas could be a prominent factor in the rotting of the brush, or, rather, in the lack of the rotting of the brush in the middle of the piles, seems hardly possible, since the temperature there is sufficiently high during a large portion of the year for fungous mycelia to grow vigorously, provided the other factors necessary for fungous growth are also present.

The precipitation in Arkansas is sufficient to supply all the moisture necessary throughout the entire brush pile for the active growth of wood-rotting fungi. It seems, therefore, that enough moisture would persist in the center of the piles for the brush to rot at least as rapidly as the pulled brush. The fact that twigs and branches in the center of piles large enough to be shaded from the rays of the sun were the only ones not rotted seems to indicate that sunlight may possibly play a part in the rotting of the brush, not only in Arkansas, but also in Arizona and New Mexico, where the same conditions as to the rotting of the limbs in the center of the piles were found to exist.[1]

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[1] Long, W. H. Op. cit., p. 395–396.

It is very evident that certain groups of fungi capable of rotting the small twigs and branches of trees which have died in the forest or of trees which have been felled are not capable of thriving under the conditions found in the center of large and compact brush piles. This is further accentuated by the fact that the bottoms of the brush piles in Arkansas, when rotted at all, are not rotted by these fungi, but are attacked by other fungi, such as *Fomes annosus*, which are known to live in more or less shaded and underground habitats.

What the factors are that dominate the growth and activity of these various groups of fungi is not known. For instance, why is it that usually *Stereum rameale* and *S. hirsutum* rarely attack limbs above 1 inch in diameter, while *S. umbrinum* and *S. versiforme* are rarely found in limbs larger than 2 or 3 inches in diameter? Why do not these fungi usually attack logs and large branches? Is the moisture content too high or the temperature too low? On the other hand, *Stereum fasciatum*, the common fungus rotting the cull logs and boles of the oak slash, usually does not attack the twigs and small branches. Of course, the explanation for this fungus might be that the twigs and small branches have not a sufficient amount of moisture, but such an explanation could not be offered for the failure of *Stereum rameale*, *S. versiforme*, and *S. umbrinum* to attack the large branches and trunks.

It would seem that but little is known concerning the real factors controlling fungous activity in wood. It is evident, however, that certain groups of fungi are capable of rotting the wood as it is normally found in nature; that is, when a tree dies, is killed by lightning, or is wind thrown. These are conditions which have been occurring in nature through centuries, and certain fungi have adapted themselves to such conditions. The same could be said of limbs and logs which are in contact with the soil, or even buried in the soil, since such conditions are normal and found generally in nature.

Apparently there are no fungi capable of vigorous growth under the artificial environments found in the center of large brush piles, where the conditions do not approximate those existing either when the brush is in contact with the soil or when it is exposed to the sunlight.

## GENERAL DISCUSSION.

Several factors, such as fire, reproduction, and the rotting of the brush, are so intimately associated that it is impossible to discuss any one phase of brush disposal without noting, at least briefly, the possible influence of these other factors. It is obviously impossible to arrive at any legitimate conclusion concerning the best method of brush disposal by limiting the discussion to the pathological side of the question as seen in the rotting of the brush itself. The fire hazard, as it seems to exist in Arkansas, is therefore briefly discussed in connection with brush disposal from the pathological viewpoint.

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[1] Long, W. H. Op. cit., p. 389–390.

In the Arkansas National Forest about 3 to 5 white-oak trees are felled to the acre, and about 5 to 10 pine trees to the acre. In the Ozark National Forest the proportion of white-oak trees felled is somewhat greater, running probably from 5 to 10 trees to the acre, while there is but very little pine cut on this forest. This means that on any area in either of these two National Forests where timber is being cut, especially white oak, a much greater percentage of standing trees of all sizes, including those below the merchantable diameter limit, is left than is cut. This standing timber will add its annual quota of fallen leaves to the ground cover, irrespective of what method of brush disposal is followed. The amount of litter in the shape of slash, on account of the small number of trees cut per acre, in many cases will not make fires more likely to start or prevent their control, since there will always be a sufficient quantity of leaf litter and underbrush present to make a good ground fire, even if there be no slash on the ground. If the deciduous trees are cut with the leaves on them the amount of leaf litter will not be increased, since these leaves would fall to the ground in the autumn even if the trees were not cut; in fact, there would really be less leaf litter on the ground, because the leaves persist on the felled tree tops and branches from one to three years.

There is also this fact to be borne in mind, that oak trees cut from November to March, inclusive, are leafless or practically so, and the brush from them will not materially increase the fire hazard unless it is piled.

In 1912 and 1913 the writer visited areas in the Ozark National Forest which were then being logged. In the studies made in 1915, only two to three years later, many of these areas had been burned over. It can probably be said truthfully that the greater portion of the Ozark National Forest, except about 100,000 acres in the middle of the central division, will be burned over at least once within a period of five years, and often within a much shorter interval. It seems, therefore, that whatever system of brush disposal is followed in this forest should take into consideration the certainty of fire as well as the rotting of the brush.

In the Arkansas National Forest many areas are not burned over more than once in every 20 years. Under such conditions the rotting of the brush is the main factor to be considered.

No areas were seen on which brush had been cut and scattered where there had been fire. What effect, therefore, a fire would have on such areas as compared with those on which brush had been piled or pulled can not be stated from actual observation. However, areas were seen on which there had been fires where brush had either been pulled or piled. Many trees whose tops had been left with the limbs unlopped were seen with the needles or leaves burned from only the lower half of the tops. This leaving unburned the leaves and needles in the upper half of the felled tree tops seemed to indicate that fires in the forests of Arkansas in pulled brush do but little, if any, more damage than the regular ground fire which is fed by the normal annual leaf débris and underbrush. Many areas on which the brush had been piled were seen where forest fires had killed a large portion of the young reproduction up to 4 inches in diameter.

Brush when lopped and piled rots much more slowly than under either of the other methods of disposal. Such piles may be expected to persist from three to six years longer than the same brush when pulled or scattered, depending upon the size and compactness of the piles. This would eliminate the large brush piles from consideration in disposing of the slash on these areas.

The best method of brush disposal over such areas would be that which is the least expensive, which reduces to a minimum the damage to the forest when fires occur, and which leaves the slash in such condition that it will rot most rapidly. It is very evident in view of these three things that the lopping and piling of the brush is the poorest method to follow, since not only is it the most expensive, but brush when piled rots the slowest and the reproduction on such areas is apparently damaged most by forest fires, judging from the burned areas seen. This would leave the choice between scattering and pulling.

Pulling, as practiced in coniferous timber, would not be practicable in certain types of hardwood sales, such as stave sales, since the oak tops are usually too heavy to be moved as a whole by the methods of logging in use on such areas. However, when tree tops fall near reproduction or near trees to be left, it is immaterial whether the top is pulled away by a team or by hand or whether the objectionable sections of the top are sawed out and rolled away.

Brush when pulled or left in the tops rots with nearly the same rapidity as when lopped and scattered. The difference in time between the rotting of the pulled and of the scattered brush is apparently about one year in favor of the scattered brush. Whether a possible maximum gain of one year in the time of rotting between the brush that is pulled and that which is scattered is sufficient to offset the difference in cost between these two methods must, of course, be considered.

## SUMMARY.

(1) When the brush is lopped and scattered it rots more rapidly than when either piled or pulled. This is due to the fact that two types of fungi rot the brush, one entering the limbs and branches not in direct contact with the ground and the other entering those portions of the brush in actual contact with the soil.

(2) The maximum gain in the rapidity of the rotting of the brush when scattered over the same brush when left unlopped in the tree tops is about one year. On dry areas, such as steep hillsides with southern and western exposures, there is practically no difference in the rate of rotting of the brush when scattered and when the tree tops are left unlopped.

(3) Brush when lopped and piled will apparently take from three to six years longer to rot than when scattered or when left unlopped.

(4) Brush when piled is rotted at the top by one group of fungi and at the bottom by another group, while the middle of the pile, not in contact with the soil and yet protected from the sunlight, apparently will not rot to any extent until the pile disintegrates sufficiently to expose these central layers to the soil moisture on the one hand or to the sunlight on the other.

(5) The same general facts as to the rotting of the slash hold for all species of timber (pine, oak, etc.) examined in Arkansas.

(6) Four fungi are the main agents in the rotting of oak slash in Arkansas, viz, *Stereum rameale*, *S. umbrinum*, *S. versiforme*, and *S. fasciatum*.

(7) Two main fungi rot the shortleaf-pine slash, viz, *Polystictus abietinus* and *Lenzites sepiaria*.

(8) No definite conclusions could be reached concerning the principal fungi which rot the bottom of the piles, since but few sporophores of such fungi were found.

(9) None of the main fungi concerned in rotting either the oak or the pine slash in Arkansas produce heart rots in living trees.

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BULLETIN No. 497
Contribution from the Forest Service
HENRY S. GRAVES, Forester.
In cooperation with the University of Washington.

Washington, D. C. PROFESSIONAL PAPER April 4, 1917

# TESTS OF WESTERN YELLOW PINE CAR SILLS, JOISTS, AND SMALL CLEAR PIECES.

By C. W. Zimmerman, *Engineer in Forest Products.*

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## INTRODUCTION.

Western yellow pine, *Pinus ponderosa*, is distributed over the greater part of the western United States, but reaches it best development in California. A variety of the species, known as *scopulorum*, occurs in the Rocky Mountains. It is a smaller tree but has the same botanical structure. Western yellow pine is long lived, attaining an age of from 350 to 500 years. The wood is camparatively weak, light, soft, and fine-grained. The heartwood is reddish-yellow, and the sapwood almost white. In some regions the wood is quite resinous; in others it is so free from resin that it is marketed as "white pine."

The tests described in the following pages were made for the purpose of gaining a definite knowledge of the mechanical properties of the wood. They began early in 1912, at the Seattle laboratory of the Forest Service, U. S. Department of Agriculture, and have been carried on in cooperation with the University of Washington. The Western Pine Manufacturers' Association contributed the test material. The tests were similar to those made by the Forest Service on Douglas fir, western hemlock, western larch, and various other species, so that a direct comparison of mechanical properties can be made.

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## MATERIAL TESTED.

The logs from which the test material was taken were cut near Springdale, Stevens County, Wash., during September, 1911, and sawed into car sills and joists at a mill at Spokane, Wash., during the same month. Representatives of the Forest Service selected the sills and joists; and, upon the arrival of the selected timbers at the Seattle laboratory, an inspector of the Pacific Coast Lumber Manufacturers' Association graded the sills in accordance with the association's export rules for 1911.

The material tested was of two classes:

(1) Car sills and joists representative of the various commercial grades found on the market. The car sills were 5 by 8 inches by 16 feet; and the joists, 2 by 10 inches by 16 feet.

(2) Small, clear pieces cut from the uninjured portions of the tested beams. Tests on these were made to determine the relative strength of wood free from knots and other natural defects, as compared to that of the various grades of market material.

## METHODS OF TEST.[1]

### BENDING.

Two methods of applying the load were used in these tests: "Third-point" loading was used for testing the large beams and center-loading for the small, clear sticks. In the "third-point" method the load is applied at two points, each one-third the length of the span from the end supports. This method of loading represents as nearly as practicable the conditions to which the beam will be subjected in structural use. Plate I shows the method of loading and of preventing buckling in the joist tests.

### COMPRESSION PARALLEL TO THE GRAIN.

In the tests in compression parallel to the grain the load was applied to the upright specimens. The specimens were of two sizes, 5 by 5 by 24 inch sticks taken from the car sills and 2 by 2 by 8 inch sticks taken from both car sills and joists.

### COMPRESSION AT RIGHT ANGLES TO THE GRAIN.

The tests in compression at right angles to the grain consisted in applying the load to an iron plate 4 inches in width and extending across the upper side of 5 by 8 by 20 inch specimens lying horizontal on the platform of the machine.

### MOISTURE DETERMINATIONS.

From each test piece a moisture disk 1 inch in thickness was cut and dried to a constant weight at 100° C. The moisture disks taken from the large beams were cut into a number of sections, in order to determine the distribution of the moisture in the timber. The proportion of moisture was found by multiplying the difference between the original and dry weights by 100 and dividing the result by the dry weight of the wood.

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[1] The methods of making the various tests on western yellow pine and the definitions of the different strength factors referred to are fully discussed in Forest Service Circular 38, "Instructions to Engineers in Timber Tests."

### WEIGHT PER CUBIC FOOT OVEN DRY.

The weight per cubic foot oven dry is based on the volume when tested and the weight oven dry. It does not represent the actual weight of wood in any condition of seasoning, and is used merely as an indication of the density of the material tested.

TABLE 1.—*Results of tests of 5-inch by 8-inch by 16-foot car sills, western yellow pine, 15-foot span, third-point loading. Green.*

| Grade. (Pacific Coast Lumber Manufacturers Association Rules for 1911.) | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. |  | Fiber stress at elastic limit per square inch. | Modulus of rupture per square inch. | Modulus of elasticity per square inch. |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  | As tested. | Oven dry. |  |  |  |
|  |  |  | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Thousands of pounds.* |
| Select: |  |  |  |  |  |  |  |  |
| Average | 6 | 18.0 | 50.7 | 38.0 | 25.2 | 3,167 | 4,910 | 1,455 |
| Maximum | 1 | 21.5 | 62.0 | 43.8 | 28.2 | 3,850 | 5,840 | 1,808 |
| Minimum | 1 | 14.2 | 33.5 | 33.3 | 22.4 | 2,400 | 4,055 | 1,140 |
| Merchantable: |  |  |  |  |  |  |  |  |
| Average | 11 | 15.3 | 37.1 | 36.1 | 26.4 | 2,828 | 4,745 | 1,224 |
| Maximum | 1 | 21.0 | 56.9 | 43.7 | 32.0 | 3,740 | 5,750 | 1,436 |
| Minimum | 1 | 9.7 | 26.2 | 29.3 | 23.2 | 2,040 | 3,830 | 990 |
| Common: |  |  |  |  |  |  |  |  |
| Average | 9 | 14.4 | 34.4 | 33.6 | 25.1 | 2,432 | 4,100 | 1,125 |
| Maximum | 1 | 17.5 | 54.3 | 35.8 | 26.9 | 3,110 | 4,935 | 1,240 |
| Minimum | 1 | 10.7 | 26.9 | 30.2 | 21.9 | 1,805 | 3,060 | 866 |
| All grades: |  |  |  |  |  |  |  |  |
| Average | 26 | 15.6 | 39.3 | 35.7 | 25.7 | 2,769 | 4,560 | 1,243 |
| Maximum | 1 | 21.5 | 62.0 | 43.8 | 32.0 | 3,850 | 5,840 | 1,808 |
| Minimum | 1 | 9.7 | 26.2 | 29.3 | 21.9 | 1,805 | 3,060 | 866 |
|  |  |  |  |  | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Select, average |  |  |  |  | 100 | 100 | 100 | 100 |
| Merchantable, average |  |  |  |  | 105 | 89 | 97 | 84 |
| Common, average |  |  |  |  | 100 | 77 | 84 | 77 |

TABLE 2.—*Results of tests of 5-inch by 8-inch by 16-foot car sills, western yellow pine, 15-foot span, third-point loading. Air seasoned.*

| Grade. | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. |  | Fiber stress at elastic limit per square inch. | Modulus of rupture per square inch. | Modulus of elasticity per square inch. |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  | As tested. | Oven dry. |  |  |  |
|  |  |  | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Thousands of pounds.* |
| Select: |  |  |  |  |  |  |  |  |
| Average | 3 | 16.6 | 12.7 | 29.9 | 26.5 | 4,020 | 6,260 | 1,614 |
| Maximum | 1 | 21.2 | 13.4 | 30.7 | 27.2 | 5,120 | 7,760 | 1,720 |
| Minimum | 1 | 13.5 | 11.4 | 28.9 | 25.9 | 2,820 | 4,460 | 1,548 |
| Merchantable: |  |  |  |  |  |  |  |  |
| Average | 13 | 14.8 | 12.6 | 30.6 | 27.2 | 4,136 | 6,395 | 1,503 |
| Maximum | 1 | 21.5 | 14.9 | 36.3 | 32.7 | 5,760 | 9,730 | 1,909 |
| Minimum | 1 | 12.1 | 11.0 | 26.6 | 23.7 | 2,713 | 3,895 | 1,191 |
| Common: |  |  |  |  |  |  |  |  |
| Average | 7 | 15.1 | 12.5 | 30.6 | 27.2 | 3,552 | 5,546 | 1,514 |
| Maximum | 1 | 19.5 | 12.9 | 32.8 | 29.0 | 4,780 | 7,780 | 1,988 |
| Minimum | 1 | 12.0 | 11.6 | 25.1 | 22.5 | 2,610 | 4,495 | 1,245 |
| All grades: |  |  |  |  |  |  |  |  |
| Average | 23 | 15.2 | 12.6 | 30.6 | 27.2 | 3,976 | 6,119 | 1,521 |
| Maximum | 1 | 21.5 | 14.9 | 36.3 | 32.7 | 5,760 | 9,730 | 1,988 |
| Minimum | 1 | 12.0 | 11.0 | 25.1 | 22.5 | 2,610 | 3,895 | 1,191 |
|  |  |  |  |  | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Select, average |  |  |  |  | 100 | 100 | 100 | 100 |
| Merchantable, average |  |  |  |  | 103 | 103 | 102 | 93 |
| Common, average |  |  |  |  | 103 | 88 | 89 | 94 |

### GENERAL OBSERVATIONS.

Before testing each specimen was weighed and measured. The proportions of sapwood and summerwood were also recorded. After the test a sketch of each specimen was made showing the failures and all natural defects. All large green beams were photographed after the test and the air-seasoned ones both before and after the test, the four sides of the timbers being shown in each case. All strength values obtained from the tests were calculated in pounds per square inch and are given in tabulated form along with the other test data.

## STRENGTH VALUES SHOWN BY THE TESTS.

### CAR SILLS.

Tables 1 and 2 give the average strength values of green and air-seasoned car sills of the commercial grades. These tables also include a comparison of the strength values of the different grades, the values of the merchantable and common grades being expressed in percentages of the values of the select grade.

### JOISTS.

The results of the tests on green and air-seasoned joists are shown in Table 3. The average values for all grades have been grouped together.

TABLE 3.—*Results of tests of 2-inch by 10-inch by 16-foot joists, western yellow pine, 15-foot span, third-point loading.*

| | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. | | Fiber stress at elastic limit per square inch. | Modulus of rupture per square inch. | Modulus of elasticity per square inch. |
|---|---|---|---|---|---|---|---|---|
| | | | | As tested. | Oven dry. | | | |
| | | | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Thousands of pounds.* |
| Green, all grades: | | | | | | | | |
| Average | 46 | 17.3 | 35.8 | 35.7 | 26.4 | 2,830 | 4,272 | 1,266 |
| Maximum | 1 | 28.0 | 123.1 | 55.2 | 35.6 | 4,047 | 6,105 | 1,706 |
| Minimum | 1 | 7.5 | 20.2 | 28.5 | 21.0 | 2,147 | 1,980 | 731 |
| Air seasoned, all grades: | | | | | | | | |
| Average | 33 | 16.7 | 13.2 | 31.6 | 28.5 | 4,502 | 6,640 | 1,595 |
| Maximum | 1 | 29.0 | 14.8 | 37.7 | 33.2 | 7,025 | 9,520 | 2,168 |
| Minimum | 1 | 10.5 | 12.2 | 25.5 | 22.5 | 1,811 | 2,320 | 1,088 |

### SMALL CLEAR PIECES.

Tables 4 and 6 give the results of the bending tests on the clear pieces taken from the tested car sills and joists. The results of tests in compression parallel to the grain, on both large and small specimens taken from the car sills, are contained in Table 5. The results of tests on small specimens taken from the joists are given in Table 7. Table 10 contains the results of a limited number of tests in compression at right angles to the grain made on clear pieces taken from the tested car sills.

## COMPARISON OF RESULTS OF TESTS ON LARGE AND SMALL PIECES.

The ratios of the average strength values in bending of small clear pieces to the average strength values of the sills and joists from which they were taken are shown in Tables 8 and 9. These tables indicate that the difference in strength between large timbers and small clear pieces is considerably smaller for the air-seasoned than for the green material. In other words, the increase in strength as the result of seasoning is less in the structural sizes than in the clear sticks. This is due to the development of defects in the large timbers during seasoning.

In the tests in compression parallel to the grain, only a slight difference was shown between the strength values of the large pieces taken from the sills and those of the small pieces taken from both the sills and joists. This is largely due to the fact that all of the specimens used in these tests were free from defects.

**TABLE 4.**—*Results of bending tests of small clear sticks taken from western yellow pine car sills, 2-inch by 2-inch by 30-inch beams, 28-inch span.*

| | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. | | Fiber stress at elastic limit per square inch. | Modulus of rupture per square inch. | Modulus of elasticity per square inch. |
|---|---|---|---|---|---|---|---|---|
| | | | | As tested. | Oven dry. | | | |
| Green: | | | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Thousands of pounds.* |
| Average | 52 | 14.9 | 36.1 | 35.5 | 25.6 | 3,156 | 5,831 | 1,178 |
| Maximum | 1 | 31.0 | 126.1 | 56.8 | 29.4 | 4,240 | 7,615 | 1,680 |
| Minimum | 1 | 7.5 | 24.9 | 27.7 | 21.7 | 2,120 | 3,910 | 775 |
| Air seasoned: | | | | | | | | |
| Average | 48 | 13.6 | 11.5 | 29.6 | 26.6 | 6,705 | 10,661 | 1,442 |
| Maximum | 1 | 28.0 | 13.7 | 39.3 | 34.6 | 9,615 | 14,840 | 1,980 |
| Minimum | 1 | 7.0 | 10.2 | 24.0 | 21.7 | 3,762 | 7,350 | 995 |

**TABLE 5.**—*Results of tests in compression parallel to grain on clear specimens taken from western yellow pine car sills.*

| Seasoning and size of sticks. | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. | | Crushing strength at maximum load per square inch. |
|---|---|---|---|---|---|---|
| | | | | As tested. | Oven dry. | |
| Green, 4 inch by 4 inch by 16 inch: | | | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Average | 25 | 14.1 | 43.2 | 35.9 | 25.0 | 2,830 |
| Maximum | 1 | 21.0 | 80.9 | 45.7 | 28.8 | 3,910 |
| Minimum | 1 | 8.0 | 27.4 | 27.4 | 21.4 | 2,195 |
| Air-seasoned, 5 inch by 5 inch by 24 inch: | | | | | | |
| Average | 23 | 11.5 | 12.5 | 29.6 | 26.3 | 5,758 |
| Maximum | 1 | 22.0 | 14.4 | 34.4 | 30.5 | 7,002 |
| Minimum | 1 | 8.0 | 11.3 | 24.8 | 22.1 | 4,460 |
| Green, 2 inch by 2 inch by 8 inch: | | | | | | |
| Average | 52 | 14.9 | 39.4 | 34.9 | 25.3 | 2,896 |
| Maximum | 1 | 31.0 | 130.4 | 57.1 | 29.5 | 3,890 |
| Minimum | 1 | 7.5 | 24.0 | 27.4 | 20.3 | 2,240 |
| Air-seasoned, 2 inch by 2 inch by 8 inch: | | | | | | |
| Average | 47 | 13.5 | 11.4 | 29.9 | 26.8 | 6,334 |
| Maximum | 1 | 28.0 | 15.7 | 38.5 | 33.3 | 8,160 |
| Minimum | 1 | 7.0 | 10.0 | 24.2 | 21.5 | 4,770 |

## RELATION BETWEEN STRENGTH VALUES.

The chart (fig. 1) showing the relation between strength values was made by plotting along one vertical line the various strength values for each green car sill and the corresponding air-seasoned sill. The order of succession of the pieces was obtained by first plotting the values for the modulus of rupture of the green sills, beginning with the maximum and descending in order. The other values for the same beams were then plotted on the same vertical lines. The chart shows that, with one exception, the strengths of the air-dry beams are in the same order as those of the green beams to which they are matched. However, the air-seasoned material shows a greater range in values than the green material. This is due, in part at least, to the variable moisture content of the air-dry sills. It will be observed that the pairs of pieces having the greater modulus of rupture in the green condition showed the larger increase in strength in air-seasoning. The other strength properties of the air-seasoned material are somewhat more erratic than those of the green. This also is partly due to variable moisture content.

Table 11 is a summary of the averages of all the preceding tables. It gives, in condensed form, the corresponding values of green and air-seasoned material of each size tested, and also the percentage of increase of those values in seasoning.

## RELATION BETWEEN PHYSICAL CHARACTERISTICS AND MECHANICAL PROPERTIES.

### DEFECTS.

The natural defects found in timber have an important influence on its strength values. In order to secure a more specific knowledge of this influence the timber was graded before being tested.

TABLE 6.—*Results of bending tests of small clear sticks taken from western yellow pine joists, 2-inch by 2-inch by 30-inch beams, 28-inch span.*

| Seasoning. | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. | | Fiber stress at elastic limit per square inch. | Modulus of rupture per square inch. | Modulus of elasticity per square inch. |
|---|---|---|---|---|---|---|---|---|
| | | | | As tested. | Oven dry. | | | |
| Green: | | | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Thousands of pounds.* |
| Average | 91 | 16.5 | 33.4 | 35.8 | 26.9 | 3,530 | 5,560 | 1,149 |
| Maximum | 1 | 41.0 | 133.7 | 58.3 | 40.8 | 6,080 | 8,530 | 1,765 |
| Minimum | 1 | 5.5 | 19.0 | 26.6 | 21.0 | 1,910 | 3,630 | 583 |
| Air seasoned: | | | | | | | | |
| Average | 58 | 17.1 | 11.7 | 30.9 | 27.6 | 6,622 | 11,045 | 1,611 |
| Maximum | 1 | 27.0 | 13.5 | 38.3 | 34.2 | 10,270 | 15,960 | 2,236 |
| Minimum | 1 | 8.0 | 10.6 | 24.8 | 22.1 | 2,890 | 6,670 | 964 |

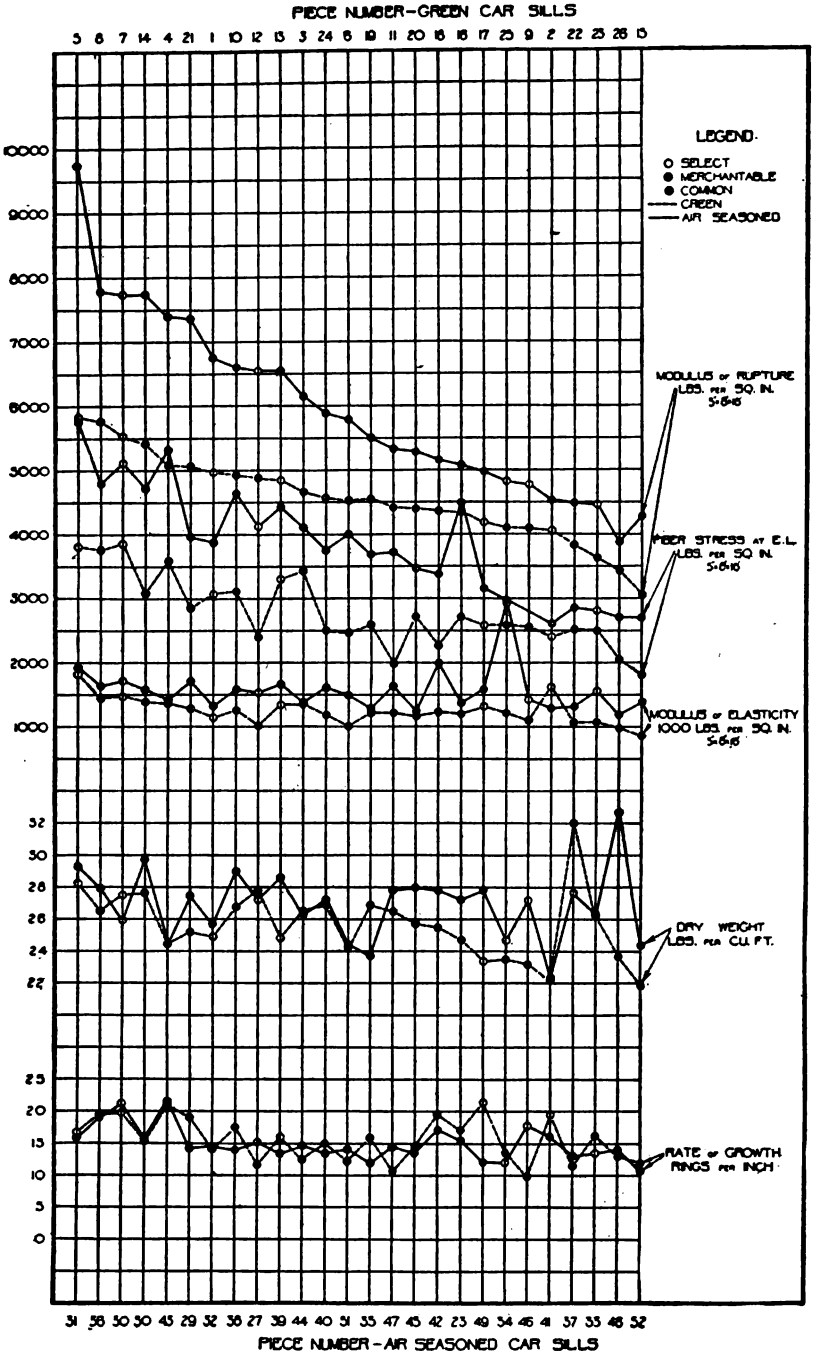


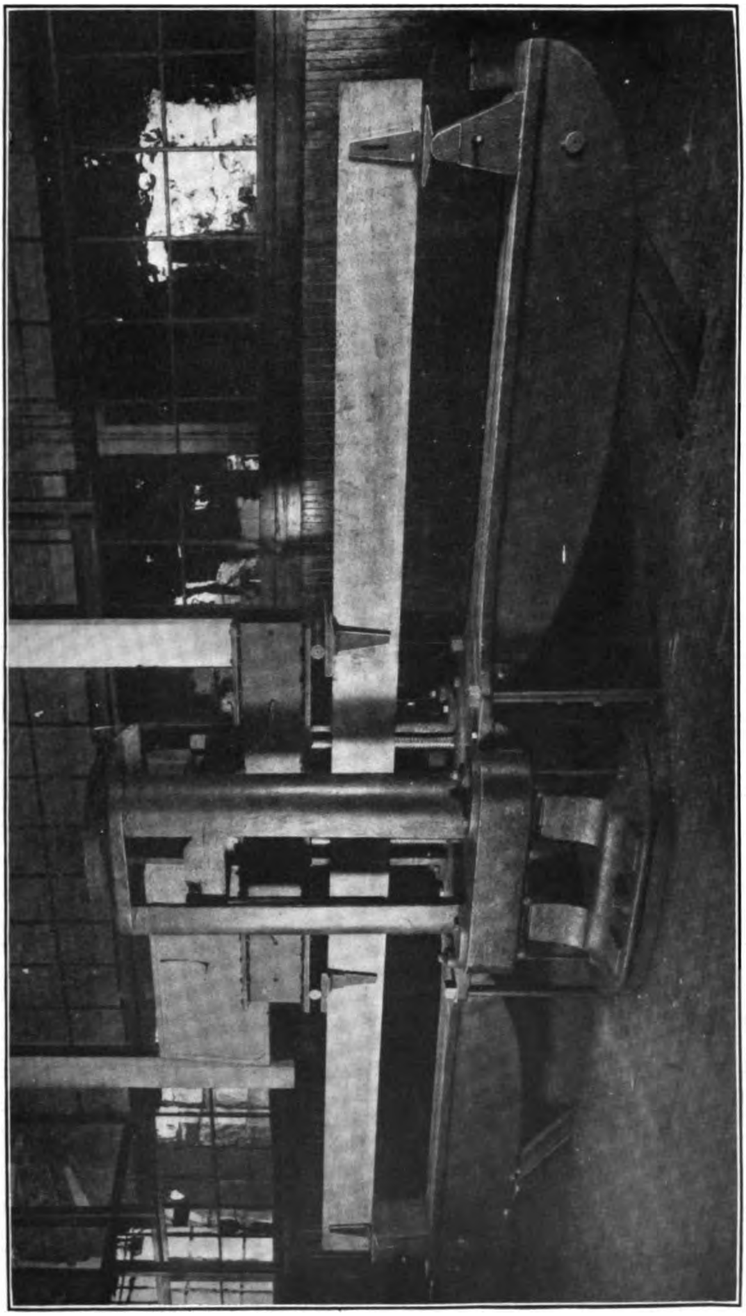
FIG. 1.—Relation between modulus of rupture and other test values for green and air-seasoned car sills.

TABLE 7.—*Results of tests in compression parallel to grain on clear specimens taken from western yellow pine joists.*

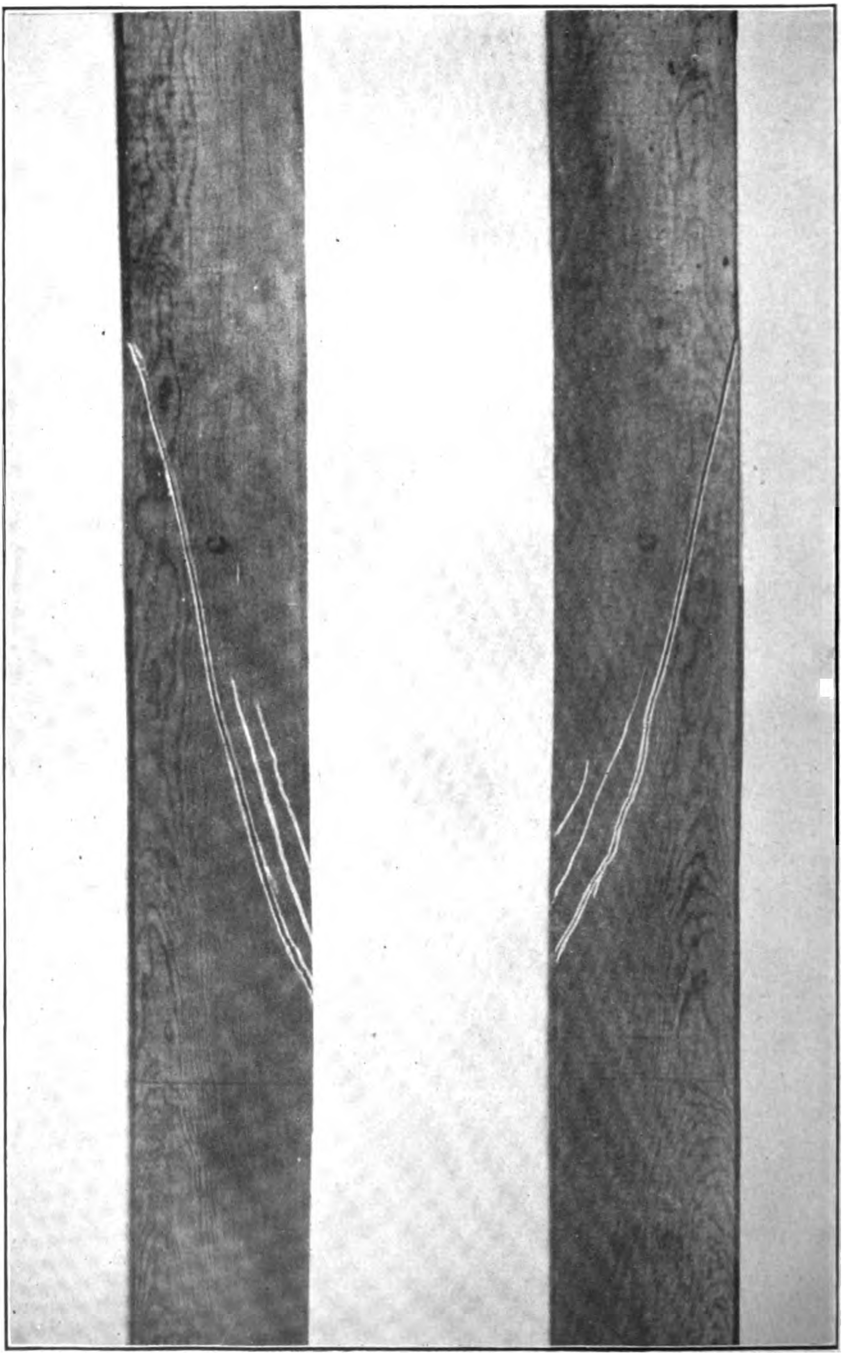
| Seasoning and size of sticks. | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. | | Crushing strength at maximum load per square inch. |
|---|---|---|---|---|---|---|
| | | | | As tested. | Oven dry. | |
| | | | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Green, 2 by 2 by 8 inches: | | | | | | |
| Average | 91 | 16.5 | 36.5 | 35.5 | 26.2 | 2,698 |
| Maximum | 1 | 41.0 | 182.7 | 61.9 | 41.4 | 3,960 |
| Minimum | 1 | 7.0 | 20.2 | 26.2 | 17.2 | 1,570 |
| Air seasoned, 2 by 2 by 8 inches: | | | | | | |
| Average | 57 | 16.5 | 11.0 | 30.3 | 27.5 | 6,550 |
| Maximum | 1 | 28.0 | 21.7 | 38.3 | 34.4 | 8,560 |
| Minimum | 1 | 8.0 | 6.8 | 22.8 | 20.2 | 4,160 |

TABLE 8.—*Ratio of average strength values in bending for all and separate grades of car sills to small clear pieces cut from them.*

| Seasoning, size, and grade. | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. | | Fiber stress at elastic limit per square inch. | Modulus of rupture per square inch. | Modulus of elasticity per square inch. |
|---|---|---|---|---|---|---|---|---|
| | | | | As tested. | Oven dry. | | | |
| | | | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Thousands of pounds.* |
| Green: | | | | | | | | |
| Select— | | | | | | | | |
| 5" x 8" x 16' | 6 | 18.0 | 50.7 | 38.0 | 25.2 | 3,167 | 4,910 | 1,455 |
| Per cent | | | | | | 98 | 80 | 114 |
| 2" x 2" x 30" | 12 | 15.5 | 38.9 | 38.4 | 25.9 | 3,229 | 6,108 | 1,281 |
| Per cent | | | | | | 100 | 100 | 100 |
| Merchantable— | | | | | | | | |
| 5" x 8" x 16' | 11 | 15.3 | 37.1 | 36.1 | 26.4 | 2,828 | 4,745 | 1,224 |
| Per cent | | | | | | 89 | 82 | 106 |
| 2" x 2" x 30" | 22 | 15.0 | 36.3 | 35.5 | 26.0 | 3,172 | 5,815 | 1,156 |
| Per cent | | | | | | 100 | 100 | 100 |
| Common— | | | | | | | | |
| 5" x 8" x 16' | 9 | 14.4 | 34.6 | 33.6 | 25.1 | 2,432 | 4,100 | 1,125 |
| Per cent | | | | | | 79 | 72 | 99 |
| 2" x 2" x 30" | 18 | 14.3 | 33.6 | 33.3 | 24.9 | 3,089 | 5,704 | 1.142 |
| Per cent | | | | | | 100 | 100 | 100 |
| All grades— | | | | | | | | |
| 5" x 8" x 16' | 26 | 15.6 | 39.3 | 35.7 | 25.7 | 2,769 | 4,560 | 1,243 |
| Per cent | | | | | | 88 | 78 | 106 |
| 2" x 2" x 30" | 52 | 14.9 | 36.1 | 35.5 | 25.6 | 3,156 | 5,831 | 1,173 |
| Per cent | | | | | | 100 | 100 | 100 |
| Air dry: | | | | | | | | |
| Select— | | | | | | | | |
| 5" x 8" x 16' | 3 | 16.6 | 12.7 | 29.9 | 26.5 | 4,020 | 6,260 | 1,614 |
| Per cent | | | | | | 59 | 61 | 113 |
| 2" x 2" x 30" | 6 | 14.2 | 12.0 | 28.5 | 25.4 | 6,791 | 10,200 | 1,434 |
| Per cent | | | | | | 100 | 100 | 100 |
| Merchantable: | | | | | | | | |
| 5" x 8" x 16' | 13 | 14.8 | 12.6 | 30.6 | 27.2 | 4,136 | 6,395 | 1,503 |
| Per cent | | | | | | 62 | 58 | 103 |
| 2" x 2" x 30" | 22 | 14.4 | 11.6 | 30.3 | 27.1 | 6,722 | 10,944 | 1,474 |
| Per cent | | | | | | 100 | 100 | 100 |
| Common— | | | | | | | | |
| 5" x 8" x 16' | 7 | 15.1 | 12.5 | 30.6 | 27.2 | 3,552 | 5,546 | 1,514 |
| Per cent | | | | | | 54 | 52 | 105 |
| 2" x 2" x 30" | 14 | 13.1 | 11.2 | 29.6 | 26.6 | 6,584 | 10,687 | 1,448 |
| Per cent | | | | | | 100 | 100 | 100 |
| All grades— | | | | | | | | |
| 5" x 8" x 16' | 23 | 15.2 | 12.6 | 30.6 | 27.2 | 3,976 | 6,119 | 1,521 |
| Per cent | | | | | | 59 | 57 | 104 |
| 2" x 2" x 30" | 42 | 13.9 | 11.5 | 29.9 | 26.7 | 6,681 | 10,751 | 1,459 |
| Per cent | | | | | | 100 | 100 | 100 |



Method of Loading and of Holding Joists to Prevent Buckling.



Typical Spiral Grain Failure in Green Western Yellow Pine Joists.

VIEW OF SIDES OF JOIST.

**Table 9.**—*Ratio of average strength values in bending for joists to small clear pieces cut from them.*

| Seasoning and size. | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. |  | Fiber stress at elastic limit per square inch. | Modulus of rupture per square inch. | Modulus of elasticity per square inch. |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  | As tested. | Oven dry. |  |  |  |
|  |  |  | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Thousands of pounds.* |
| Green: |  |  |  |  |  |  |  |  |
| 2" x 10" x 16′ | 46 | 17.3 | 35.8 | 35.7 | 26.4 | 2,830 | 4,272 | 1,266 |
| Per cent |  |  |  |  |  | 80 | 77 | 110 |
| 2" x 2" x 30" | 91 | 16.5 | 33.4 | 35.8 | 26.9 | 3,530 | 5,560 | 1,149 |
| Per cent |  |  |  |  |  | 100 | 100 | 100 |
| Air seasoned: |  |  |  |  |  |  |  |  |
| 2" x 10" x 16′ | 33 | 16.7 | 13.2 | 31.6 | 28.5 | 4,502 | 6,640 | 1,595 |
| Per cent |  |  |  |  |  | 68 | 60 | 99 |
| 2" x 2" x 30" | 58 | 17.1 | 11.7 | 30.9 | 27.6 | 6,622 | 11,045 | 1,611 |
| Per cent |  |  |  |  |  | 100 | 100 | 100 |

**Table 10.**—*Results of tests in compression perpendicular to grain on clear specimens, 5-inch by 8-inch by 20-inch, taken from western yellow pine car sills.*

|  | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot. |  | Compressive strength at elastic limit per square inch. |
|---|---|---|---|---|---|---|
|  |  |  |  | As tested. | Oven dry. |  |
| Green: |  |  | *Per cent.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Average | 25 | 15.6 | 42.9 | 36.8 | 25.6 | 299 |
| Maximum | 1 | 21.5 | 69.8 | 45.8 | 28.7 | 413 |
| Minimum | 1 | 9.7 | 26.9 | 31.2 | 21.1 | 179 |
| Air seasoned: |  |  |  |  |  |  |
| Average | 26 | 13.3 | 13.0 | 30.5 | 27.0 | 701 |
| Maximum | 1 | 20.0 | 17.4 | 40.7 | 34.6 | 1,110 |
| Minimum | 1 | 8.0 | 11.5 | 24.1 | 21.5 | 315 |

**TABLE 11.**—*Average strength values for green and air-seasoned western yellow pine in structural sizes and small pieces without defects.*

GREEN MATERIAL.

| Cross section. | Bending. | | | | | | | Compression parallel to grain. | | | | Compression perpendicular to grain. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of tests. | Rings per inch. | Moisture. | Weight per cubic foot, oven dry. | Fiber stress at elastic limit per square inch. | Modulus of rupture per square inch. | Modulus of elasticity per square inch. | Size of specimen. | Number of tests. | Moisture. | Crushing strength at maximum load per square inch. | Size of specimen. | Number of tests. | Moisture. | Compressive strength at elastic limit per square inch. |
| *Inches.* | | | *Per cent.* | *Lbs.* | *Lbs.* | *Lbs.* | *1,000 lbs.* | *Inches.* | | *Per cent.* | *Lbs.* | *Inches.* | | *Per cent.* | *Lbs.* |
| 5 x 8 | 26 | 15.6 | 39.3 | 25.7 | 2,769 | 4,560 | 1,243 | 4 x 4 x 16 | 25 | 43.2 | 2,830 | 5 x 8 x 20 | 25 | 42.9 | [illegible] |
| 2 x 10 | 46 | 17.3 | 35.8 | 26.4 | 2,830 | 4,272 | 1,266 | ........ | .... | ...... | ...... | ........ | .... | ...... | ...... |
| 2 x 2 | 143 | 15.9 | 34.4 | 26.4 | 3,394 | 5,659 | 1,159 | 2 x 2 x 8 | 143 | 37.6 | 2,770 | ........ | .... | ...... | ...... |
| AIR-SEASONED MATERIAL. | | | | | | | | | | | | | | | |
| 5 x 8 | 23 | 15.2 | 12.6 | 27.2 | 3,976 | 6,119 | 1,521 | 5 x 5 x 24 | 23 | 12.5 | 5,758 | 5 x 8 x 20 | 26 | 13.0 | [illegible] |
| 2 x 10 | 33 | 16.7 | 13.2 | 28.5 | 4,502 | 6,640 | 1,595 | ........ | .... | ...... | ...... | ........ | .... | ...... | ...... |
| 2 x 2 | 106 | 15.5 | 11.6 | 27.1 | 6,660 | 10,871 | 1,534 | 2 x 2 x 8 | 104 | 11.2 | 6,457 | ........ | .... | ...... | ...... |
| RATIO—AIR-SEASONED TO GREEN. | | | | | | | | | | | | | | | |
| 5 x 8 | .... | ...... | ...... | ...... | 144 | 134 | 122 | 4 x 4 x 16<br>and<br>5 x 5 x 24 | .... | ...... | 204 | 5 x 8 x 20 | .... | ...... | 234 |
| 2 x 10 | .... | ...... | ...... | ...... | 159 | 156 | 126 | ........ | .... | ...... | ...... | ........ | .... | ...... | ...... |
| 2 x 2 | .... | ...... | ...... | ...... | 196 | 192 | 132 | 2 x 2 x 8 | .... | ...... | 233 | ........ | .... | ...... | ...... |

The results of tests on green car sills (Table 1) show the weakening effect of knots to be directly proportional to their size and quantity, the lower grades of timber having larger knots and a greater number of them. Table 2, in which the air-seasoned sills are given, shows a greater increase in strength through air seasoning in the lower grades than in the clear sills.

The material tested contained no shakes. The checking in air seasoning was practically the same as that which usually occurs in Douglas fir, western hemlock, and western larch.

Failure because of spiral grain was quite frequent in the green joists. This grain is very difficult to detect, the surface grain often appearing straight and the resin ducts indistinct. Plate II is an excellent illustration of this.

Both the joists and the car sills contained an unusual amount of sapwood, but this in no way altered the strength of the material under consideration. However, because of its lack of durability, sapwood is undesirable in timbers used under conditions favorable to decay.

### RATE OF GROWTH.

The effect of the rate of growth on strength was studied in small, clear pieces, for there are so many factors which influence the strength of material in structural sizes that it is impossible to draw any conclusions regarding the effect of rate of growth from the results of tests on such timbers.

Figure 2 shows the relation of the strength values obtained from the various tests to the number of rings per inch. The small number at each circle on the curve indicates the number of tests used to obtain that average. It will be observed that the maximum strength values are reached in pieces having a rate of growth approximately 20 rings to the inch.

The modulus of rupture varies considerably with the rate of growth, while the remaining factors are influenced to a less degree.

The dry weight increases with the number of rings per inch until it reaches its maximum at 26 rings per inch and remains about constant thereafter.

### DRY WEIGHT.

Without question, the dry weight of wood, all other things being equal, is the best criterion of its strength. But in order to obtain reliable and definite results it was deemed advisable to study the effect of this factor in small, clear pieces only, as in the case of the rate of growth. Figure 3, in which the results of the tests are given, shows that the various strength factors increase with the dry weight of the wood, the greatest increase being in the modulus of rupture.

### SEASONING.

The results of moisture determinations made on the car sills and joists tested are indicated in figure 4. The green car sills show an average moisture content for the entire section of 39.2 per cent; the green joists, an average moisture content of 35.7 per cent. In the case of both car sills and joists the outer portion of the green beams showed a smaller moisture content than the intermediate portions. This variation was doubtless caused by slight surface seasoning before testing. The air-seasoned car sills showed an average moisture content for the whole section of 12.6 per cent and the joists 13.3 per cent. The moisture content within the sections varied but slightly, increasing from the minimum in the outer portion to the maximum in the inner portion. The material tested was all air seasoned under cover, the car sills for about 16 months and the joists for 14 months.

### EFFECT OF SEASONING UPON STRENGTH.

Seasoning, as a rule, increases the strength of wood. Although a lowering of the moisture content is accompanied by an increase

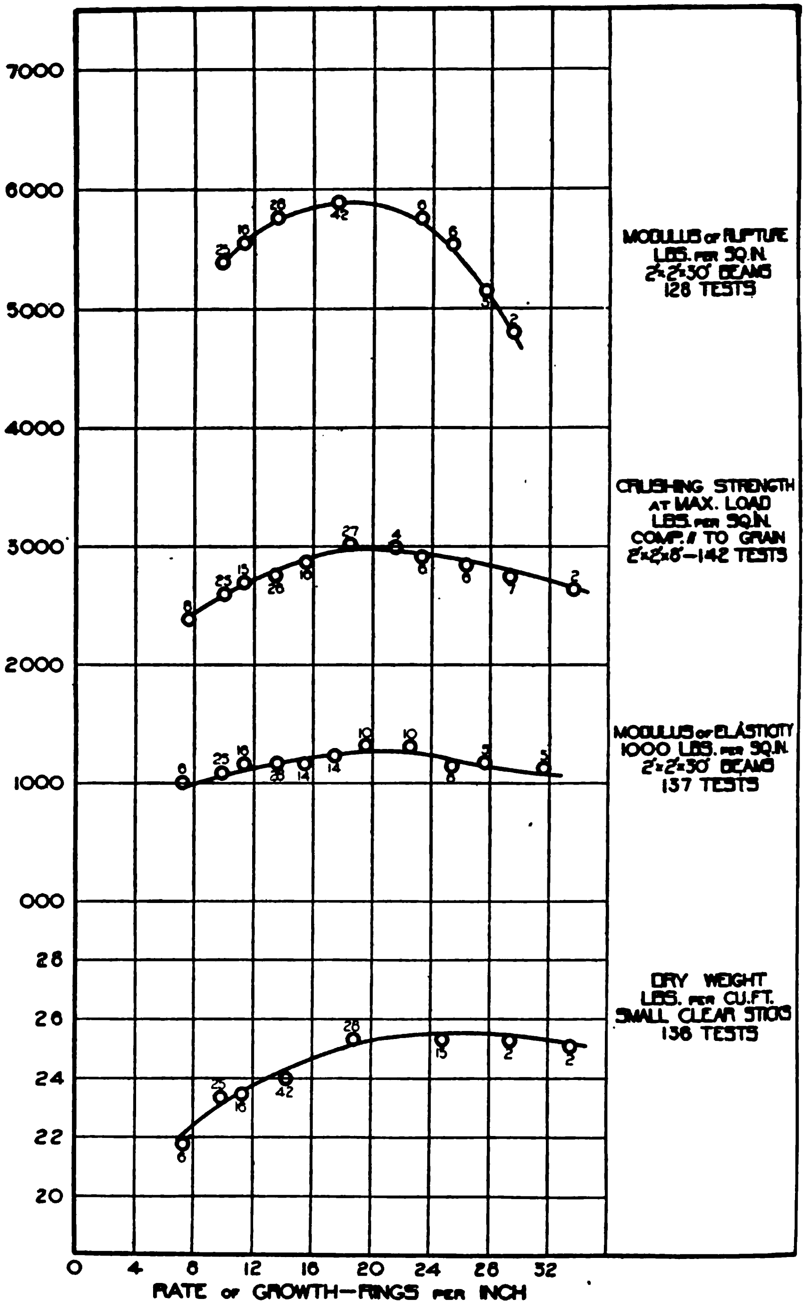


Fig. 2.—Relation of density and strength values to rate of growth in small, clear pieces of green western yellow pine.

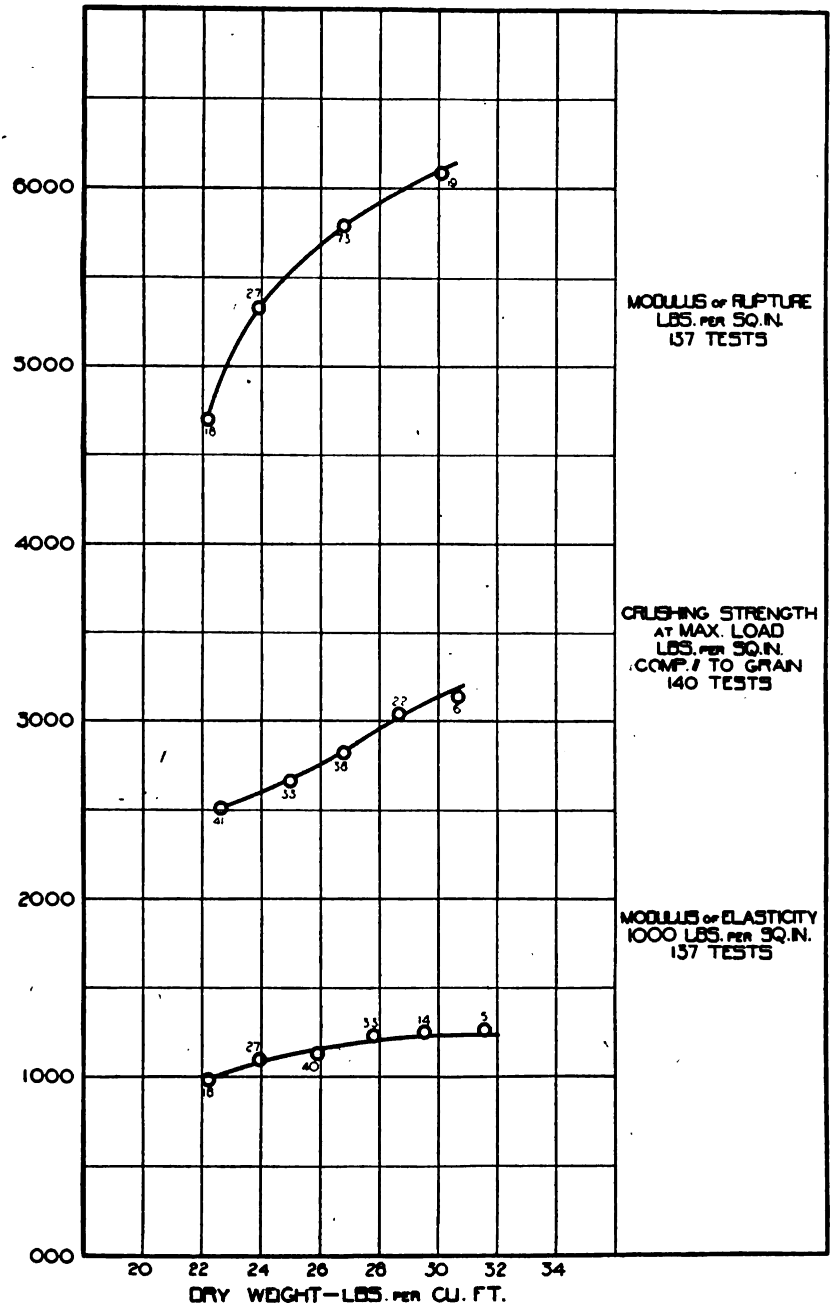
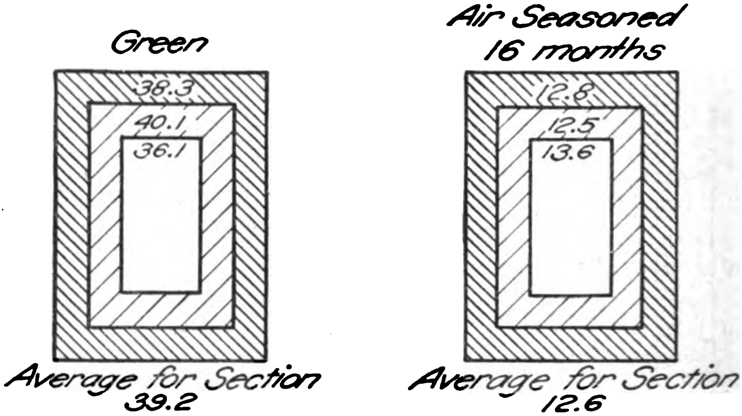
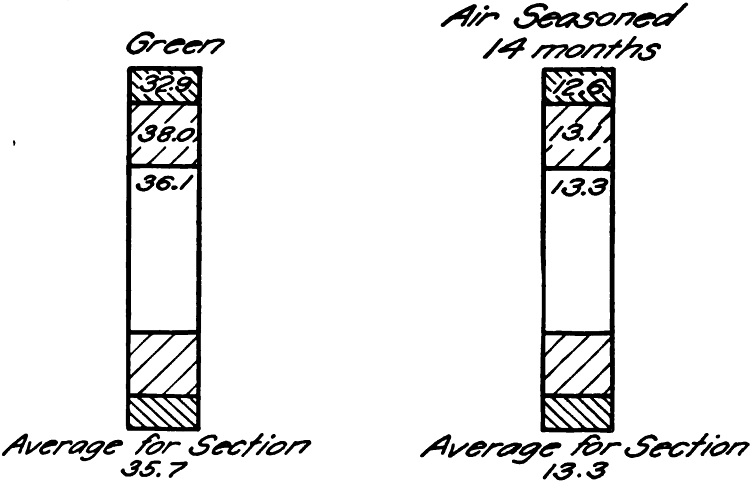


FIG. 8.—Relation of strength values to dry weight in small, clear sticks of green western yellow pine.

in strength in any wood, the gain is somewhat greater for small, clear pieces than for timbers in structural sizes. Seasoning does not, as a rule, cause any appreciable defects in small pieces, but in large beams often develops defects in the form of checks which counterbalance the strength gained in seasoning. A comparison of the strength values of green and air-seasoned car sills is given in figure 1. The effect of seasoning upon the strength of test material of various sizes is indicated in Table 12.



*Average moisture distribution in sections cut from green and air-seasoned car sills.*



*Average moisture distribution in sections cur from green and air-seasoned joists.*

FIG. 4.—Summary of moisture determinations made upon green and seasoned joists and car sills of western yellow pine.

## CONCLUSIONS.

The comparatively small number of experiments made on western yellow pine limits the conclusions to be drawn regarding this species to the following:

(*a*) The strength values of structural timbers are influenced considerably by the defects found in them. These values vary according to the grades in the green material; but the increase in strength from air seasoning is not uniform and does not vary with the grades.

(*b*) Seasoning greatly increases the strength of the wood, the increase being greater and more uniform in small, clear sticks than in structural timbers, owing to the development of defects in the latter. Lowering the moisture content of yellow pine causes it to become more brittle.

(*c*) Western yellow pine is a lighter wood than the other western lumber species, weighing approximately 26.9 pounds per cubic foot, oven dry, in structural sizes. The dry weight of clear wood readily suggests its strength or weakness, but this factor alone can not be depended upon to indicate comparative strength when structural forms of various grades are taken into consideration, owing to the presence of defects which have an important influence on their strength.

(*d*) The table of comparison of the strengths of various western species (Table 12) is based on tests of small, clear specimens. In addition to the results of tests on western yellow pine, as previously described, there are included average values derived from similar tests on material from five trees from each of four other localities. In comparing species from data in this table it is well to base comparisons on results of tests of green material, since differences in moisture content of green material do not produce differences in strength. It must also be remembered that the figures given are averages and that the variability of timber is such that individual specimens of a species may excel the average for another species which averages considerably higher, or they may fall below the average for a species which averages considerably lower. When values from tests of air-dry materials are used for comparison careful attention should be given to the moisture content of the material compared (whether it is of two or more species or of one species from two or more localities) and the effect of differences of moisture considered. The effect of moisture and the methods for adapting strength values from one moisture content to another are gone into in Forest Service Bulletin 70, "Effect of Moisture on the Strength and Stiffness of Wood."

TABLE 12.—*Weight, shrinkage, and mechanical properties of several western species as determined from tests on small specimens free from defects and tested while green and after thorough air drying.*

| Species. | Locality where grown. | Weight per cubic foot. | | | Shrinkage from green to oven-dry condition. | | | Moisture content at which tests were made. | Static bending. | | | | Impact bending 50-pound hammer; height of drop causing complete failure. | Compression parallel to grain—crushing strength at maximum load per square inch. | Compression perpendicular to grain. Fiber stress at elastic limit per square inch. | Hardness; load required to embed a 0.444-inch ball to one-half its diameter (Jank's ball test). | | Shearing strength parallel to grain per square inch. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Kiln dry about 8 per cent moisture. | Air dry about 12 or 15 per cent moisture. | Green. | Volume. | Radial. | Tengential. | | Fiber stress at elastic limit per square inch. | Modulus of rupture per square inch. | Modulus of elasticity per square inch. | Work to maximum load per cubic inch. | | | | End. | Side. | |
| | | *Lbs.* | *Lbs.* | *Lbs.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *Lbs.* | *Lbs.* | *Thousands of lbs.* | *Lbs.* | *Ins.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* | *Lbs.* |
| Port Orford cedar (*Chamæcyparis lawsoniana*) | Douglas County, Oreg. | 30 | 31 | 39 | 10.7 | 5.2 | 8.1 | 52.0 | 3,920 | 6,800 | 1,500 | 7.8 | 25 | 3,280 | 380 | 560 | 480 | 880 |
| | | | | | | | | 9.0 | 8,880 | 14,510 | 2,040 | 12.1 | 39 | 7,750 | 1,020 | 950 | 700 | 1,500 |
| Western red cedar (*Thuja plicata*) | Snohomish County, Wash. | 23 | 24 | 30 | 8.6 | 2.5 | 5.6 | 45.2 | 3,620 | 5,730 | 1,020 | 5.6 | 18 | 3,050 | 350 | 462 | 272 | 742 |
| Amabilis fir (*Abies amabilis*) | do | 26 | 27 | 36 | 14.1 | 4.5 | 10.0 | 65.8 | 3,540 | 5,660 | 1,260 | 6.0 | 21 | 2,670 | 290 | 360 | 310 | 670 |
| Douglas fir (*Pseudotsuga taxifolia*) | Washington and Oregon. | 34 | 35 | 38 | 12.7 | 5.1 | 7.8 | 35.4 | 4,920 | 7,800 | 1,580 | 6.6 | 25 | 3,910 | 530 | 510 | 470 | 870 |
| | | | | | | | | 15.9 | 6,300 | 9,760 | 1,680 | | | 4,850 | | | | 940 |
| Noble fir (*Abies nobilis*) | Multnomah County, Oreg. | 27 | 28 | 31 | 13.6 | 4.9 | 9.1 | 41.2 | 3,420 | 5,690 | 1,280 | 6.2 | 20 | 2,700 | 310 | 300 | 250 | 700 |
| Western hemlock (*Tsuga heterophylla*) | Grays Harbor and Buckley, Wash. | 30 | 31 | 40 | | | | 52.0 | 4,410 | 7,290 | 1,430 | | | 3,390 | | | | |
| | | | | | | | | 17.0 | 6,330 | 10,370 | 1,670 | | | 5,400 | | | | |
| Western larch (*Larix occidentalis*) | Stevens County, Wash. | 33 | 34 | 42 | | | | 46.0 | 4,270 | 7,250 | 1,310 | | | 3,700 | | | | |
| | | | | | | | | 14.8 | 5,890 | 10,230 | 1,560 | | | 5,940 | | | | |
| Western yellow pine (*pinus ponderosa*) | Coconino County, Ariz. | 25 | 26 | 44 | 9.2 | 4.1 | 6.4 | 98.0 | 2,660 | 4,760 | 880 | 4.9 | 17 | 2,220 | 340 | 310 | 310 | 660 |
| | | | | | | | | 11.6 | 6,350 | 8,150 | 1,100 | 4.6 | 10 | 5,220 | 790 | 550 | 410 | 1,300 |
| Do. | Madera County, Cal. | 28 | 29 | 53 | 11.5 | 4.3 | 7.3 | 125.0 | 3,180 | 5,180 | 1,110 | 4.3 | 21 | 2,420 | 330 | 320 | 310 | 700 |
| | | | | | | | | 9.7 | 8,160 | 11,060 | 1,460 | 8.2 | 19 | 6,600 | 800 | 560 | 510 | 1,210 |
| Do. | Douglas County, Colo. | 28 | 29 | 49 | 9.9 | 3.8 | 5.8 | 93.0 | 3,310 | 5,460 | 1,050 | 6.0 | 20 | 2,600 | 410 | 320 | 330 | 710 |
| | | | | | | | | 13.8 | 6,230 | 9,400 | 1,260 | 7.0 | 18 | 4,920 | 710 | 620 | 450 | 1,030 |
| Do. | Missoula County, Mont. | 27 | 28 | 51 | 9.3 | 3.5 | 5.9 | 119.0 | 2,930 | 4,950 | 860 | 5.2 | 19 | 2,370 | 310 | 310 | 320 | 670 |
| | | | | | | | | 7.8 | 7,100 | 9,620 | 1,350 | 6.0 | 19 | 6,740 | 800 | 570 | 490 | 1,080 |
| Do.[1] | Stevens County, Wash. | | | | | | | 34.4 | 3,390 | 5,660 | 1,160 | | | 2,770 | 300 | | | |
| | | | | | | | | 11.6 | 6,060 | 10,870 | 1,530 | | | 6,460 | 700 | | | |
| Sitka spruce (*Picea sitchensis*) | Lewis County, Wash. | 25 | 26 | 32 | 11.2 | 4.5 | 7.4 | 53.0 | 3,020 | 5,490 | 1,180 | 6.4 | 29 | 2,600 | 330 | 430 | 370 | 780 |
| Western yew (*Taxus brevifolia*) | Snohomish County, Wash. | 43 | 45 | 54 | 9.7 | 4.0 | 5.4 | 44.1 | 6,520 | 10,110 | 990 | 20.2 | 38 | 4,650 | 1,040 | 1,340 | 1,150 | 1,620 |
| | | | | | | | | 9.2 | 10,100 | 16,750 | 1,460 | 18.4 | 30 | 9,300 | 5,040 | 2,340 | 1,700 | 2,470 |

[1] Results taken from Table 2. NOTE.—Results opposite common name of species are from tests of green material; those opposite botanical name, from tests of air-dry material.

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UNITED STATES DEPARTMENT OF AGRICULTURE
**BULLETIN No. 498**
Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ February 19, 1917

# EXPERIMENTS WITH SPRING CEREALS AT THE EASTERN OREGON DRY-FARMING SUBSTATION MORO, OREG.

By

DAVID E. STEPHENS, Station Superintendent
Office of Cereal Investigations

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UNITED STATES DEPARTMENT OF AGRICULTURE

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**WM. A. TAYLOR, Chief**

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## INTRODUCTION.

The Eastern Oregon Dry-Farming Substation[1] was established at Moro, Oreg., in 1909. The land was purchased and the buildings (fig. 1) erected with funds contributed by Sherman County. The expense of maintenance is borne jointly by the Oregon Agricultural Experiment Station and the Bureau of Plant Industry.

A cooperative agreement between the Bureau of Plant Industry and the Oregon Agricultural Experiment Station specifies that "The objects of the cooperative investigations shall be (*a*) to improve the cereals of the Pacific coast region by introducing or producing better varieties than those now grown, especially with regard to drought resistance, yield, quality, earliness, etc.; (*b*) to determine the best methods of cultivation and crop rotation for grain production; and (*c*) to conduct such other experiments as may seem advisable for the accomplishment of the greatest possible good to the cereal interests of the State of Oregon." Full credit is given to the Oregon Agricultural Experiment Station and to Sherman County for their share in obtaining the cooperative results reported in this publication.

---

[1] From the establishment of the Moro substation until November, 1911, Mr. H. J. C. Umberger was superintendent. In February, 1912, the writer was appointed superintendent.

Some preliminary work was done in 1910, but most of the experiments were not started until 1911. The investigational work at Moro comprises tests of methods of production and improvement of cereals, including crop rotation and tillage. This bulletin deals only with the varietal tests of spring-sown cereals, including wheat, emmer, oats, barley, and grain sorghums.

## DESCRIPTION OF THE STATION.

The Eastern Oregon Dry-Farming Substation is located in the southwestern part of the Columbia Basin,[1] near Moro, in Sherman County, Oreg. Eastern Oregon, as the term is used locally, refers to all that portion of the State east of the Cascade Mountains. Sherman County lies along the Columbia River, the northern border of the State. It is really about midway of the State from east to west. Moro is about 15 miles from the Columbia River, on a branch line of the Oregon-Washington Railroad & Navigation Co. A map of the State, on which the location of the substation is indicated, is shown in figure 2.

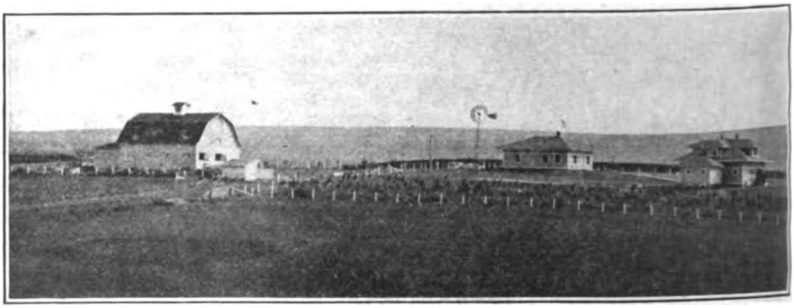

FIG. 1.—General view of the station buildings at the Eastern Oregon Dry-Farming Substation, at Moro.

The elevation of the substation is approximately 2,000 feet. The soil and climatic conditions at Moro are typical of a large part of the Columbia Basin. It is believed, therefore, that the results obtained at the substation are applicable in a general way to most of the Columbia Basin, but especially to districts where the prevailing soil type is silt loam and where the annual average precipitation ranges from 9 to 12 inches.

The substation comprises 233 acres, about 200 of which are tillable. Like most of the Columbia Basin lands, the surface is very rolling, nearly every direction and inclination of slope being represented. On the experimental plats the slopes vary from nearly level land to a rise of 11 feet per 100. A contour map of the substation is shown in figure 3.

---

[1] For a general description of the Columbia Basin, see Hunter, Byron, Farm practice in the Columbia Basin uplands, U. S. Dept. Agr., Farmers' Bul. 294, 30 p., 1907.

For the purpose of comparing the soil and climatic conditions at Moro with those of other localities, a brief description is given of the soil and climate at the substation.

### SOIL.

The soil at the substation is the fine silt loam characteristic of a large portion of the Columbia Basin. It is classified by the Bureau of Soils as Yakima silt loam. It is derived largely from the decomposition of the basaltic or lava rock by which it is underlain. Unlike some of the soils nearer the Columbia River, the percentage of sand is not high enough to cause trouble from soil shifting or blowing. The soil is easily worked and requires little cultivation to put it in good tilth, the only implements really necessary for making a good seed bed being a plow and a spike-tooth harrow. The disk harrow, however, is frequently used prior to plowing, and a bar weeder for surface cultivation of the summer fallow. According to Bradley,[1] the general composition of eastern Oregon soils, of which the substation soil is typical, is as shown in Table I.

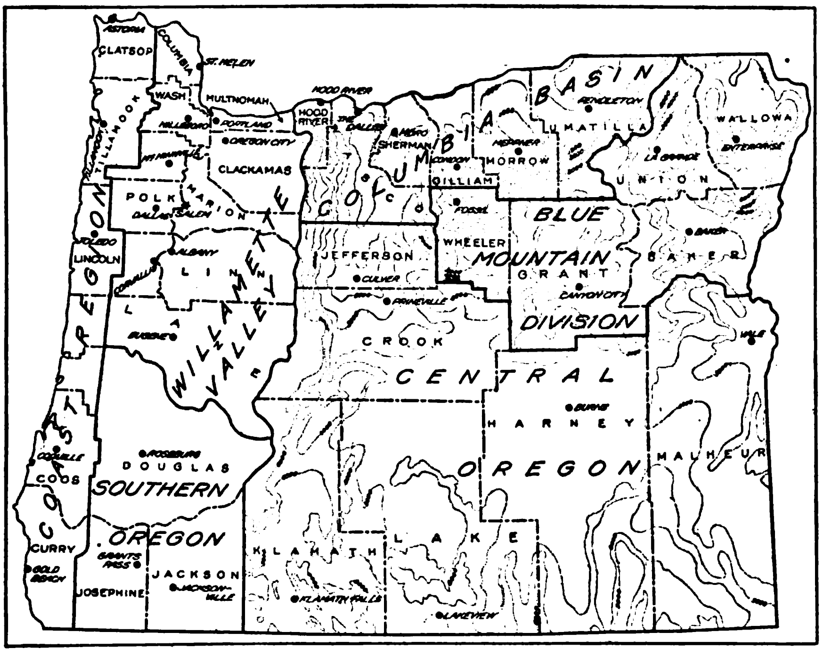

FIG. 2.—Map of Oregon, showing contour lines east of the Cascade Range and the location of the Eastern Oregon Dry-Farming Substation, at Moro.

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[1] Bradley, C. E. Soils of Oregon. Oreg. Agr. Expt. Sta. Bul. 112, 48 p. 1912.

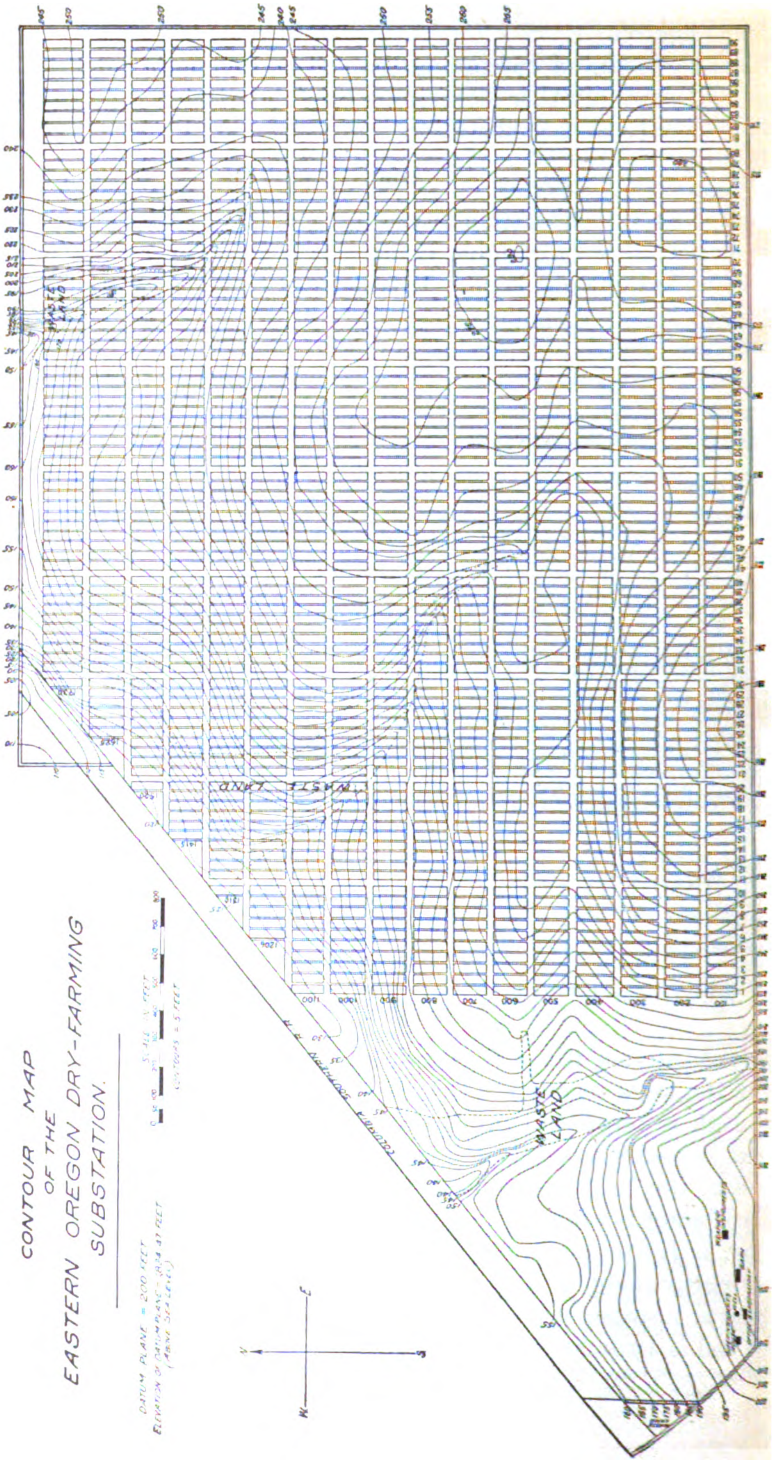

FIG. 3.—Contour map of the Eastern Oregon Dry-Farming Substation, Moro, Oreg., showing the method of dividing the farm into plats.

TABLE I.—*Composition of silt loam soil in the Columbia Basin.*

| Constituents. | Total. | Soluble in 1.115 HCl. | Constituents. | Total. | Soluble in 1.115 HCl. |
|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | | *Per cent.* | *Per cent.* |
| Silica ($SiO_2$) | 62.85 | 0.34 | Iron and aluminum oxids ($Fe_2O_3$ and $Al_2O_3$) | 8.47 | 8.37 |
| Potash ($K_2O$) | 1.63 | .74 | Phosphoric acid ($P_2O_5$) | .30 | .21 |
| Lime ($CaO$) | 4.52 | 3.05 | Nitrogen (N) | .11 | ........ |
| Magnesia ($MgO$) | 1.94 | 1.66 | Volatile | .37 | ........ |
| Manganese oxid ($Mn_3O_4$) | .04 | ........ | | | |

From analyses of surface soil obtained from both virgin and cropped areas Bradley concludes that "while the percentage of nitrogen in these soils has remained practically constant under continual cropping for, in extreme cases, 25 years, there has been a marked decrease in the carbon or organic content." Probably on account of this deficiency in humus the surface soil at the substation is inclined to run together or pack in the spring from the effects of winter precipitation.

The soil is remarkably uniform in texture, absorbs water readily, and has a high moisture-holding capacity. At the substation the depth of the soil to the rock formation underneath varies from 1 to 9 feet, the deeper soil being on the higher elevations and on the northward slopes. Where the ground slopes toward the west or southwest, the soil usually is shallow and therefore less suited to cereal production, because of its inability to store sufficient moisture to mature crops. Most of the farm had been cropped to grain for about 25 years prior to the establishment of the substation.

## CLIMATIC CONDITIONS.

Careful records of climatological phenomena have been kept since January, 1910, in cooperation with the Biophysical Laboratory of the Bureau of Plant Industry. The weather-observing equipment consists of standard snow and rain gauges, maximum and minimum thermometers, self-recording thermographs, an evaporation tank, an anemometer, and a psychrometer.

### PRECIPITATION.

In no other place in the world is cereal production conducted on such an extensive scale with so little precipitation as in the Columbia Basin. As Table II shows, the lowest annual precipitation in the vicinity of Moro during the past 10 years has been 7.68 inches. The precipitation for the years from 1905 to 1909, inclusive, was recorded at Grass Valley, which is about 10 miles south of Moro, while that for the years 1910 to 1915, inclusive, was recorded at the substation. The average annual precipitation for the 11-year period from 1905 to 1915 is 11.35 inches. The highest annual precipitation since records have been kept at the substation is 14.89 inches.

TABLE II.—*Monthly and annual precipitation at Grass Valley and Moro, Oreg., showing the average, maximum, and minimum for each month, from 1905 to 1915, inclusive.*

[Precipitation data (in inches): Previous to December, 1909, from the Oregon-Washington Railroad & Navigation Co., Grass Valley, Oreg.; since December, 1909, from the substation records. T=trace.]

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905 | 0.76 | 0.20 | 0.05 | 0.03 | 1.70 | 1.30 | 0.36 | T | 0.75 | 1.36 | 0.85 | 1.35 | 8.71 |
| 1906 | 1.00 | .85 | 1.65 | .10 | 1.05 | 1.85 | T | .34 | .35 | T | 2.59 | 2.22 | 12.00 |
| 1907 | 2.65 | .48 | 1.60 | 1.06 | .90 | .89 | .30 | .71 | .50 | .20 | 1.46 | 2.68 | 13.43 |
| 1908 | .55 | .02 | .68 | .11 | 1.41 | .37 | .22 | .34 | .12 | 1.11 | 1.12 | 1.63 | 7.68 |
| 1909 | 2.56 | 1.03 | .68 | .10 | .49 | .99 | .10 | .02 | .45 | .87 | 3.34 | 1.14 | 11.77 |
| 1910 | .95 | 1.47 | .63 | .66 | 1.25 | .89 | T | .00 | .20 | .70 | 2.76 | .88 | 10.39 |
| 1911 | 1.18 | .46 | .25 | .35 | 1.05 | .64 | .00 | T | 4.03 | .33 | .30 | .61 | 9.20 |
| 1912 | 3.58 | 1.36 | .69 | .78 | 1.33 | .42 | .02 | .74 | .21 | .78 | 1.30 | 2.12 | 13.33 |
| 1913 | 1.33 | .23 | .76 | .58 | 2.27 | 1.39 | .06 | .05 | .49 | 1.87 | 1.45 | 1.69 | 12.17 |
| 1914 | 2.20 | 1.16 | .11 | 2.06 | .76 | .66 | .08 | T | 1.05 | 1.48 | .88 | .88 | 11.32 |
| 1915 | 1.75 | 2.31 | 1.27 | .65 | 2.06 | .36 | .57 | .05 | 1.14 | .23 | 2.89 | 1.61 | 14.89 |
| Average | 1.68 | .87 | .76 | .59 | 1.30 | .89 | .16 | .20 | .84 | .81 | 1.72 | 1.53 | 11.35 |
| Maximum | 3.58 | 2.31 | 1.65 | 2.06 | 2.27 | 1.85 | .57 | .74 | 4.03 | 1.87 | 3.34 | 2.58 | 14.89 |
| Minimum | .55 | .02 | .05 | .03 | .49 | .37 | .00 | .00 | .12 | T | .30 | .61 | 7.68 |

The distribution of the precipitation usually is favorable for growing cereals, nearly all of the rain falling during the months from September to June. July and August are practically rainless. In some years there is considerable run-off in the winter or early spring (fig. 4). Soil samples taken to a depth of 6 feet on 20 plats in May, 1913, had an average of only 1 per cent more moisture than samples taken on the same plats in November, 1912, though the precipitation during the interval measured 5.5 inches. From September 1, 1914, to February 28, 1915, the precipitation was 8.35 inches, but this penetrated stubble ground to a depth of less than 2 feet. The rains

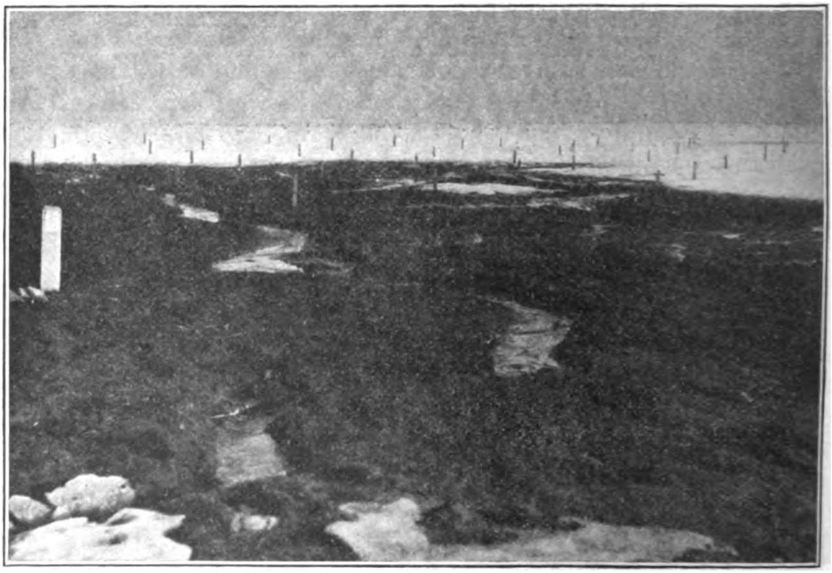

FIG. 4.—Experimental plats at the Moro substation in the spring of 1916, showing the run-off during the melting of a heavy covering of snow.

which occur during the late spring, summer, and autumn months are of such a nature that practically all of the water is absorbed by the soil, but much of the winter precipitation is frequently lost as run-off. As is shown in Table II, the wettest months are November, December, and January. Much of the precipitation during these months is usually in the form of snow.

The 11-year average precipitation by months is shown graphically in figure 5.

The precipitation available for growing cereals during any particular season in this section is largely that which falls from September 1 to August 31. In comparing crop production with precipitation data, therefore, records for calendar years are not so valuable as those for crop years ending August 31. The precipitation which falls during the growing season is also an important factor in influencing crop yields. The average seasonal precipitation for small grains (March to July, inclusive), as shown in Table III, is 3.83 inches.

Table III gives precipitation records for each of the five crop years for which results are reported in this bulletin, 1911 to 1915, inclusive, and also the precipitation for the growing season in each of those years.

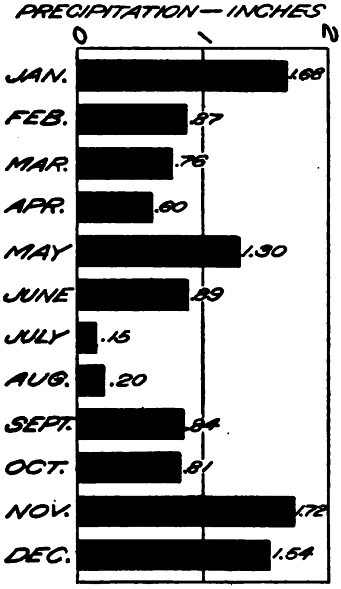

FIG. 5.—Diagram showing the average monthly precipitation in inches at Moro, Oreg., during the 11 years from 1905 to 1915.

TABLE III.—*Precipitation at Moro, Oreg., in crop years (ending Aug. 31) and in the growing season (March to July, inclusive), for five years, 1911 to 1915, inclusive.*

| Period. | Inches. | Period. | Inches. |
|---|---|---|---|
| Annual: | | Seasonal: | |
| Sept. 1, 1910, to Aug. 31, 1911 | 8.47 | Mar. 1 to July 31, 1911 | 2.29 |
| Sept. 1, 1911, to Aug. 31, 1912 | 14.19 | Mar. 1 to July 31, 1912 | 3.24 |
| Sept. 1, 1912, to Aug. 31, 1913 | 11.08 | Mar. 1 to July 31, 1913 | 5.06 |
| Sept. 1, 1913, to Aug. 31, 1914 | 12.53 | Mar. 1 to July 31, 1914 | 3.67 |
| Sept. 1, 1914, to Aug. 31, 1915 | 13.31 | Mar. 1 to July 31, 1915 | 4.91 |
| Average | 11.92 | Average | 3.83 |

It will be observed that the crop year of 1912, from the standpoint of precipitation, was the most favorable for crop production of any of the five years for which data are here given. The crop year of 1911 was very unfavorable, the total precipitation being only 8.47 inches, of which only 2.29 inches fell during the growing season. The average for the five years ending August 31 is 0.57 inch more than the 11-year average, and the average for the growing season in the five years is 0.13 inch more than the 11-year average for the same months.

### EVAPORATION.

Records of evaporation from a free water surface have been kept during the seven months, April to October, inclusive, in the years 1911 to 1915, inclusive. The method used is the same as at other stations cooperating with the Biophysical Laboratory of the Bureau of Plant Industry.[1] The evaporation tank at Moro is 2 feet deep and 6 feet in diameter. Table IV gives the monthly evaporation, April to October, inclusive, in the years 1911 to 1914, inclusive.

TABLE IV.—*Evaporation, in inches, from a free water surface at Moro, Oreg., in the seven months, April to October, inclusive, for five years, 1911 to 1915, inclusive.*

| Month. | 1911 | 1912 | 1913 | 1914 | 1915 | Average. |
|---|---|---|---|---|---|---|
| April | 5.92 | 4.51 | 4.09 | 4.02 | 5.13 | 4.73 |
| May | 6.13 | 6.75 | 6.24 | 7.43 | 5.90 | 6.50 |
| June | 9.61 | 7.75 | 7.36 | 8.29 | 8.45 | 8.29 |
| July | 11.57 | 7.89 | 7.90 | 11.43 | 9.05 | 9.57 |
| August | 9.28 | 6.72 | 7.82 | 9.64 | 9.59 | 8.61 |
| September | 4.16 | 4.50 | 4.82 | 4.40 | 5.30 | 4.64 |
| October | 2.34 | 2.60 | 3.52 | 2.20 | 2.98 | 2.73 |
| Total | 49.01 | 40.72 | 41.75 | 47.41 | 46.40 | 45.07 |

The highest evaporation occurred in 1911, when the evaporation for the seven months was approximately five times greater than the total precipitation for that year. The lowest evaporation was in 1912, when the ratio of the evaporation for the seven months to the total precipitation for the year was about 3 to 1. During the 6-month period from April to September, inclusive, the average evaporation at the substation in the years from 1911 to 1915, inclusive, was 42.34 inches. This is greater than the evaporation reported by Briggs and Belz[1] during a 6-month period at any station north of the fortieth parallel of latitude (the northern boundary of Kansas).

Table V shows the evaporation and precipitation and the winter-wheat yields at the Moro substation and two other representative dry-farming stations, one in the Great Basin at Nephi, Utah, at an elevation of nearly 6,000 feet, and one in the northern Great Plains at Moccasin, Mont., at an elevation of 4,300 feet. The wheat yields reported in Table V were produced under the same method, alternating wheat with summer fallow, at all the stations. Investigations similar to those conducted at Moro are being carried on at Nephi and at Moccasin. The precipitation and evaporation data are taken from the records of the Biophysical Laboratory and the wheat yields from the records of the Office of Cereal Investigations.

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[1] Briggs, L. J., and Belz, J. O. Dry farming in relation to rainfall and evaporation. U. S. Dept. Agr., Bur. Plant Indus. Bul. 188, p. 16–20. 1910.

Data are available for the years 1909 to 1915 at Moccasin, for the years 1908 to 1915 at Nephi, and for the years 1911 to 1915 at Moro.

TABLE V.—*Precipitation and evaporation data and yields of winter and spring wheat at Moccasin, Mont., Nephi, Utah, and Moro, Oreg., in the years indicated.*

| Character of data. | Moccasin, 1909 to 1915. | Nephi, 1908 to 1915. | Moro, 1911 to 1915. |
|---|---|---|---|
| Average precipitation: | | | |
| Annual........inches.. | 16.66 | 12.78 | 12.18 |
| Seasonal (April to August, inclusive)........do.... | 9.06 | 5.15 | 3.39 |
| Average evaporation: | | | |
| Seasonal (April to August, inclusive)........do.... | 27.96 | 38.71 | 37.70 |
| Ratio of annual precipitation to seasonal evaporation........ | 1:1.68 | 1:3 | 1: 3.2 |
| Ratio of seasonal precipitation to seasonal evaporation........ | 1:3.1 | 1:7.5 | 1:11.2 |
| Average yield of best winter wheat........bushels.. | 35.7 | 25 | [a] 23 |
| Average yield of best spring wheat........do.... | 27.6 | 10 | 22.1 |

[a] Average yield of 10 plats of Turkey wheat in tillage experiments.

The average annual precipitation and the average seasonal precipitation are greater at Moccasin and at Nephi than at Moro. The average evaporation from April to August, inclusive, is 1.01 inches greater at Nephi and 9.74 inches less at Moccasin than at Moro. The ratio of annual precipitation to seasonal evaporation is slightly greater at Moro than at Nephi, but there is a wide difference between the ratios of seasonal precipitation and seasonal evaporation at Moro and the other two stations.

## TEMPERATURE.

Table VI gives the highest, lowest, and mean temperatures for each month of the years 1911 to 1915, inclusive, and also the average of the means, the average of the maxima, and the average of the minima by months for the 5-year period.

TABLE VI.—*Mean, maximum, and minimum temperatures at Moro, Oreg., by months, for five years, 1911 to 1915, inclusive.*

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mean:** | | | | | | | | | | | | |
| 1911........ | 30.3 | 30.6 | 43.5 | 46.2 | 51.0 | 60.6 | 70.0 | 66.0 | 54.8 | 46.9 | 38.0 | 34.0 |
| 1912........ | 29.3 | 36.8 | 37.9 | 45.7 | 54.6 | 61.4 | 66.0 | 62.5 | 55.0 | 44.9 | 40.7 | 33.0 |
| 1913........ | 29.5 | 28.8 | 38.2 | 46.6 | 54.6 | 60.4 | 67.9 | 68.0 | 57.6 | 47.3 | 40.7 | 28.0 |
| 1914........ | 36.5 | 33.3 | 43.8 | 47.6 | 56.2 | 59.5 | 70.5 | 69.1 | 55.5 | 49.5 | 38.1 | 22.8 |
| 1915........ | 29.0 | 36.0 | 45.0 | 50.8 | 53.0 | 60.0 | 64.8 | 71.3 | 57.3 | 50.6 | 38.2 | 32.8 |
| Average... | 30.5 | 33.1 | 41.7 | 46.6 | 53.9 | 59.6 | 67.8 | 67.4 | 56.0 | 47.8 | 39.1 | 28.6 |
| **Maximum:** | | | | | | | | | | | | |
| 1911........ | 55 | 46 | 77 | 74 | 86 | 89 | 103 | 89 | 87 | 75 | 61 | 53 |
| 1912........ | 51 | 52 | 65 | 68 | 86 | 96 | 98 | 97 | 85 | 69 | 61 | 54 |
| 1913........ | 53 | 58 | 57 | 75 | 83 | 89 | 101 | 99 | 88 | 74 | 57 | 47 |
| 1914........ | 51 | 38 | 69 | 72 | 88 | 91 | 99 | 100 | 83 | 69 | 59 | 46 |
| 1915........ | 41 | 52 | 70 | 75 | 78 | 93 | 96 | 100 | 86 | 73 | 54 | 53 |
| Average... | 50.2 | 49.2 | 67.6 | 72.8 | 84.2 | 91.6 | 99.4 | 97.0 | 85.8 | 72.0 | 58.4 | 50.6 |
| **Minimum:** | | | | | | | | | | | | |
| 1911........ | 5 | 9 | 11 | 22 | 30 | 32 | 44 | 42 | 34 | 32 | 4 | 5 |
| 1912........ | −6 | 26 | 20 | 28 | 33 | 37 | 43 | 38 | 31 | 25 | 23 | 19 |
| 1913........ | 5 | 7 | 9 | 28 | 36 | 37 | 41 | 41 | 33 | 28 | 29 | 10 |
| 1914........ | 28 | 28 | 27 | 29 | 32 | 34 | 42 | 43 | 29 | 32 | 19 | −3 |
| 1915........ | 10 | 23 | 30 | 32 | 34 | 40 | 40 | 46 | 36 | 33 | 25 | 11 |
| Average... | 8.4 | 18.6 | 19.4 | 27.8 | 33.0 | 36.0 | 42.0 | 42.0 | 32.6 | 30.0 | 20.0 | 8.2 |

Table VII shows the dates of the latest spring frosts and the earliest autumn frosts, together with the minimum temperature recorded for those dates in the years 1911 to 1915, inclusive. It will be observed from this table that during the five years no frost occurred in June, July, or August. None of the frosts recorded on the dates mentioned in Table VII did any damage to cereals. The longest frost-free period was in 1915, 211 days, and the shortest frost-free period in 1914, 108 days. The average frost-free period for the five years is 155.8 days.

TABLE VII.—*Data relating to killing frosts at the Moro substation in the years 1911 to 1915, inclusive.*

| Year. | Last in spring. | | First in autumn. | | Frost-free period. |
|---|---|---|---|---|---|
| | Date. | Temperature. | Date. | Temperature. | |
| | | °F. | | °F. | Days. |
| 1911 | May 8 | 32 | Oct. 17 | 32 | [illegible] |
| 1912 | Apr. 29 | 31 | Sept. 3 | 31 | [illegible] |
| 1913 | Apr. 27 | 31 | Oct. 15 | 32 | [illegible] |
| 1914 | May 27 | 32 | Sept. 12 | 32 | [illegible] |
| 1915 | Apr. 8 | 32 | Nov. 5 | 30 | [illegible] |
| Average | May 2 | | Oct. 5 | | [illegible] |

## WIND.

The prevailing winds at Moro are from the west, southwest, and northeast. Southwest or west winds usually are accompanied by cool or moderately warm weather in the summer and mild weather in winter, while east or northeast winds are nearly always accompanied by high temperatures in summer and low temperatures in winter. Though wind velocities are never exceedingly high, the wind movement is quite constant from about March 1 to August 31. The number of miles of wind during any 24-hour period rarely exceeds 350, 490 miles being the highest number recorded at the substation for any one day of 24 hours during the years 1911 to 1915, inclusive.

Table VIII gives the average wind velocity in miles per hour for each month of the years 1911 to 1915, inclusive.

TABLE VIII.—*Average wind velocity (in miles per hour), by months, at the Moro substation in the years 1911 to 1915, inclusive.*

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Average. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1911 | 5.3 | 5.4 | 6.3 | 9.6 | 9.2 | 11.8 | 9.4 | 9.2 | 7.2 | 4.8 | 6.7 | 5.5 | [illegible] |
| 1912 | 3.7 | 4.9 | 6.1 | 8.4 | 7.8 | 5.9 | 5.6 | 5.3 | 2.8 | 2.0 | 2.9 | 4.1 | [illegible] |
| 1913 | 2.4 | 2.8 | 5.9 | 7.3 | 8.3 | 6.9 | 5.9 | 6.3 | 3.8 | 5.0 | 4.0 | 2.7 | [illegible] |
| 1914 | 5.4 | 5.0 | 5.6 | 6.5 | 7.1 | 8.8 | 8.8 | 7.5 | 6.0 | 4.0 | 4.5 | 2.9 | [illegible] |
| 1915 | 3.2 | 4.0 | 4.7 | 6.7 | 5.4 | 8.2 | 8.1 | 7.5 | 7.0 | 6.1 | 4.3 | 5.4 | [illegible] |
| Average | 4.0 | 4.4 | 5.7 | 7.7 | 7.5 | 8.2 | 7.6 | 7.2 | 5.2 | 4.4 | 4.5 | 4.5 | [illegible] |

Table VIII shows that June is the windiest month, though there is little difference in the monthly averages for any month from April to August, inclusive. The highest average wind velocity for any year in the 5-year period was 7.5 miles per hour, in 1911. The year 1911 was also the one with the least precipitation and the greatest evaporation.

## EXPERIMENTAL METHODS.

The experimental work with cereals is conducted for the following purposes: (1) To ascertain what grain varieties are best adapted to the drier districts of the Columbia Basin, (2) to improve the best adapted varieties by selective breeding, (3) to determine what crop-rotation systems will prove most profitable in connection with grain raising, and (4) to find out the most economical and profitable methods of soil tillage for cereal production in this section.

The work with spring grains during the first few years was along two lines, the testing of varieties and the improvement of varieties by pure-line selections. No work in hybridization has been attempted. A large number of pure lines have been developed, some of which give promise of being of considerable value. In this bulletin only the results of the varietal experiments will be given.

In the testing of varieties, field plats and nursery rows are used, the unit of comparison being a tenth-acre or twentieth-acre in the plat experiments and 1-rod or 2-rod replicated rows in the nursery experiments. Eight-rod rows and eightieth-acre plats also have been used in the nursery. While a rather careful study is made of the varieties in the nursery and in the plat experiments and numerous notes taken on the habits of the plants, the value of a variety has been judged largely by its yield of grain.

### DIMENSIONS OF PLATS.

As shown in figure 3, the substation farm is laid out in series of tenth-acre plats 8 rods long and 2 rods wide. The series are separated by roads 16½ feet wide and are divided into blocks of 10 plats each by roads of the same width. Alleys 4½ feet wide separate the individual plats within these blocks.

When twentieth-acre plats were used, each tenth-acre plat was divided in half by an alley 22 inches wide. The twentieth-acre plats discussed in this bulletin actually contain only 2,062.5 square feet, or 115.5 square feet less than one-twentieth of an acre. In computing yields per acre, however, no account has been taken of this shortage. Acre yields computed from the yields of small plats are likely to be slightly exaggerated on account of the increased proportion of margin.

The plan first adopted at the substation for the varietal experiments was to grow a single tenth of an acre of each variety, with every fifth plat sown uniformly to one variety and regarded as a check. The two methods described in previous publications[1] have been used to determine relative or computed yields, but neither has proved entirely satisfactory. The variation in check-plat yields of spring grains usually has not been great. Occasionally, however, wide variations occur in the yields of check plats which can not be explained in any satisfactory manner.

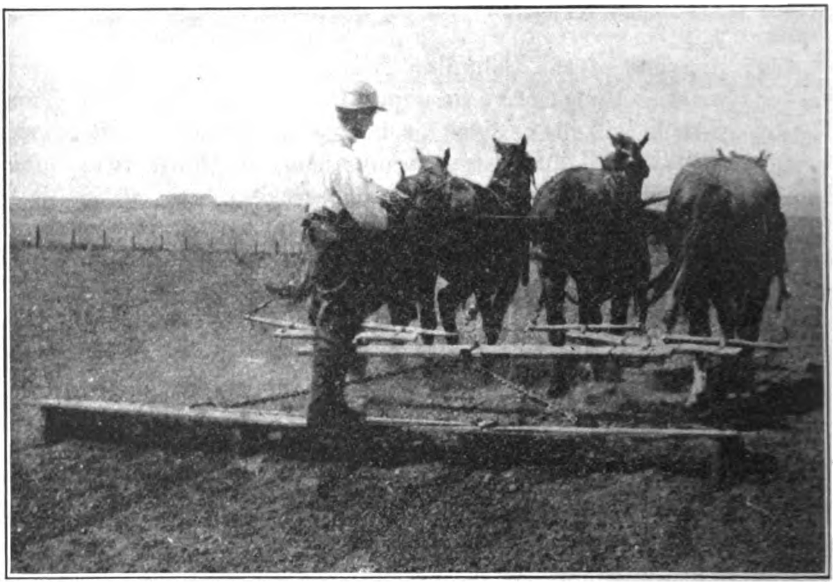

FIG. 6.—A bar weeder, or "slicker," in operation at the Eastern Oregon Dry-Farming Substation.

Beginning with 1913, each variety of spring grain in a varietal test has been sown in duplicate twentieth-acre plats. The plats in the two series are arranged as follows:

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

All yields in this bulletin are reported in bushels per acre, based on the actual yields of a single tenth-acre or the average actual yields of two twentieth-acre plats.

## TREATMENT OF PLATS.

The general practice in growing cereals in the Columbia Basin is to alternate a grain crop with bare fallow, commonly called summer fallow. This alternation has been followed almost without exception in the varietal experiments at the substation. The station crops have been produced by the methods in general use by the farmers in this section, and the yields reported are about those which ordinarily may be expected. The land is plowed 7 to 8 inches deep in April, an early spring disking usually being given prior to plowing. Immediately after plowing, the ground is harrowed once with a spike-tooth harrow, and another harrowing is given when weed growth starts. Later in the season, in order to eradicate weeds, the plats are cultivated with a weeder, locally known as a bar weeder. If necessary, this implement is used again later, the aim being to keep the fallow ground free from weeds. In order to accomplish this it sometimes has been necessary to cultivate so frequently that the soil has been too finely pulverized. The soil at the substation, if cultivated too much, may become so compacted after the winter snows and rains that much of the precipitation of winter and early spring is lost as run-off instead of being absorbed. Figure 6 shows the bar weeder in operation, and figure 7 shows the condition in which the fallow is usually kept during the summer months.

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[1] Cardon, P. V. Cereal investigations at the Nephi substation. U. S. Dept. Agr. Bul. 30, p. 12, 33. 1913. Clark, J. Allen. Cereal experiments at Dickinson, N. Dak. U. S. Dept. Agr. Bul. 33, p. 11, 12. 1914.

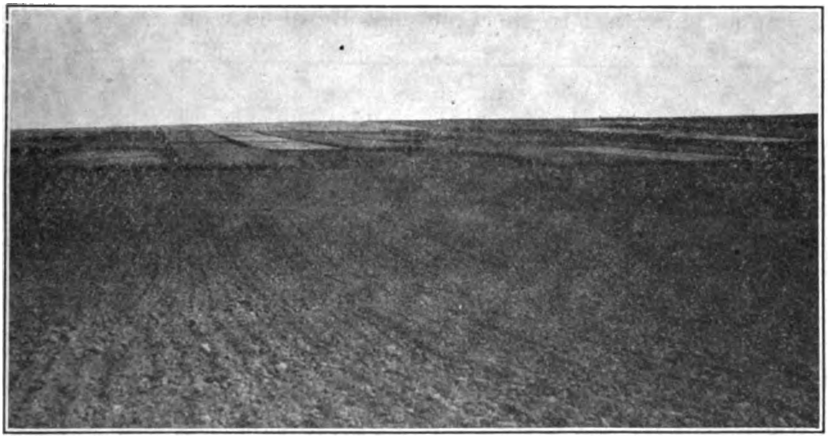

FIG. 7.—Plats of the rotation experiments at the Moro substation, showing summer-fallow land in almost ideal condition in the foreground and small grains and corn in the background. Photographed in July, 1914.

Just prior to seeding spring grains, the ground is double disked and then harrowed once. Seeding is done with a disk drill, and no cultivation is given after seeding.

The land in the vicinity of the substation is infested with several weeds that have been found difficult to control in the experimental plats. The two most troublesome in spring grains are the Russian thistle (*Salsola pestifer*) and tumbleweed (*Amaranthus graecizans*). Where good stands of grain are obtained the latter weed is rarely found, but the Russian thistle sometimes has been troublesome, especially in early-sown spring grain and in grain with thin stands.

In the experimental plats the weeds have been destroyed by hand hoeing.

All varieties are carefully rogued to free them from accidental mixtures. They are cut with a binder, shocked, and then thrashed several weeks later with a small separator run by a gasoline engine. The grain from each plat is weighed after thrashing and the bushel weight determined. No straw weights have been recorded. The rows and small plats are thrashed with a small separator designed for that purpose.

## CEREAL EXPERIMENTS.

### SPRING WHEAT.

From the standpoint of total production in bushels, spring wheat is not as important in the Columbia Basin as winter wheat. Considerable spring wheat is grown, however, on account of the fact that dry weather frequently prevails until so late in the autumn that winter wheat can not be sown with safety. Winter wheat is better adapted to the present summer-fallow system of grain production in the Columbia Basin, because it permits a better distribution of farm labor. Winter wheat also usually gives yields somewhat higher than those of spring wheat.

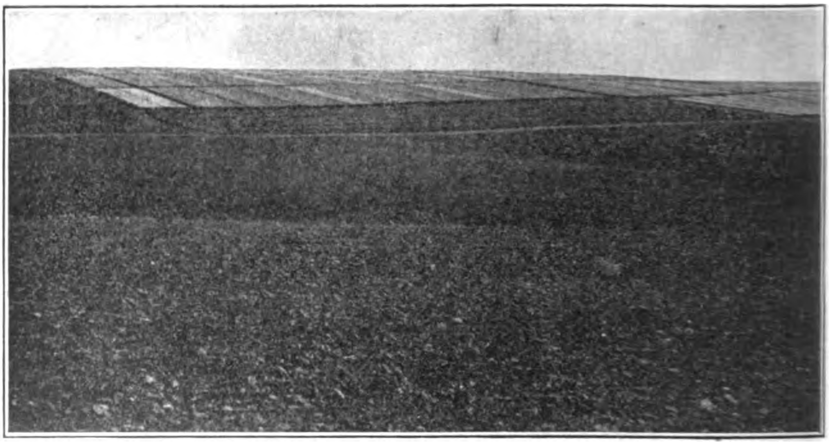

FIG. 8.—Varietal plats of spring grain at the Moro substation, showing summer-fallow land in the foreground. Photographed July, 1914.

Many wheat varieties, like Pacific Bluestem and Little Club, are sown in the Columbia Basin in either the autumn or spring, except on the higher elevations.

#### VARIETAL EXPERIMENTS.

Seventy-seven varieties of spring wheats have been tried at the substation. Some of these, which did not appear to be at all adapted, were discarded after a 2-year trial. New varieties have been added from time to time, and 5-year average yields have been obtained for only seven varieties. Table IX gives the annual acre yields of all the spring-wheat varieties which have been tested. In this table the varieties are arranged in alphabetical order, without regard to the period during which they were grown, their rank in yield, or other relationships. Figure 8 shows a portion of the plats in the varietal experiments with spring grain in 1914.

TABLE IX.—*Spring-wheat varieties tested at the Moro substation, showing the yields obtained in each year the variety was grown during the five years, 1911 to 1915, inclusive.*

| Variety. | C. I. No. | Division. | Origin. | Yield per acre (bushels).[a] | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1911 | 1912 | 1913 | 1914 | 1915 |
| Abd-el-Kader | 2075 | Durum | Tunis | 11.1 | 15.5 | | | |
| Alaska | | Poulard | Southern Europe | | | 13.6 | 15.0 | [b] 9.4 |
| Aulieata | 2407-1 | Common | Turkestan | [b] 1.5 | [c] 9.4 | [c] 9.4 | | |
| Do | 2407-2 | do | do | [b] 8.3 | [c] 31.2 | 23.0 | 22.9 | 20.2 |
| Barbilla | 2944 | do | Teneriffe | [c] 8.4 | [d] 12.6 | | | |
| Beseler Squarehead | 2681 | do | Germany | [c] 7.7 | [d] 11.0 | | | |
| Black Persian | 2823 | do | Argentina | (e) | (e) | [b] 8.9 | [b] 3.1 | [b] 6.6 |
| Blé Noir | 2511-2 | Durum | Abyssinia | 3.5 | 7.5 | 18.0 | 18.3 | 23.6 |
| Bluestem. (See Pacific Bluestem.) | | | | | | | | |
| Bobs | 2826-1 | Common | Australia | [b] 13.8 | [c] 18.3 | [c] 15.6 | 24.7 | 25.4 |
| Bola Blanca | 2921-1 | Club | Mexico | [b] 4.2 | (e) | [c] 12.7 | [b] 14.6 | [d] 16.5 |
| Chul | 2227 | Common | Turkestan | 11.2 | 12.9 | | | |
| Do | 2227-1 | do | do | [b] 13.6 | [b] 17.8 | [c] 14.0 | 21.5 | 20.2 |
| Dale Gloria | 4155 | Club | Oregon (?) | 3.8 | 8.6 | 18.3 | 18.0 | |
| Early Baart | 1697 | Common | Australia | 14.5 | 19.0 | 25.0 | 26.0 | 26.6 |
| Elephant | 2824-1 | do | do | (e) | [b] 12.0 | [c] 10.1 | [b] 3.1 | [b] 13.6 |
| Erivan | 2397-1 | do | Russia | (e) | (e) | (e) | [b] 12.4 | [c] 10.2 |
| Fishhead | 1732 | do | China | [c] 9.8 | [d] 12.8 | | | |
| Galgalos | 2398 | do | Russia | 7.8 | 12.8 | | | |
| Do | 2398-1 | do | do | (e) | [c] 14.2 | [c] 8.0 | (e) | [b] 14.6 |
| Ghirka Spring | 1517 | do | do | | | 19.6 | 16.2 | 26.1 |
| Glyndon (Minn. No. 163). | 2873 | do | Minnesota | 9.1 | 12.3 | 16.6 | | |
| Heine Squarehead | 2669 | do | Germany | [c] 10.1 | [d] 20.0 | 21.6 | 22.5 | 23.6 |
| Hurma | 2124-3 | Durum | Arabia | [c] 12.9 | [d] 7.0 | | | |
| Hybrid No. 63 | 4157 | Club | Washington | | 15.5 | 20.6 | 15.3 | |
| Hybrid No. 108 | 5025 | do | do | [c] 6.7 | 8.6 | [c] 13.6 | [d] 3.3 | |
| Japanese | 1787 | Common | Japan | 12.1 | 14.3 | | | |
| Kahla | 2088-4 | Durum | Algeria | [b] 11.4 | [c] 7.5 | (e) | [b] 6.7 | [b] 8.0 |
| Karun | 2200-1 | Common | Persia | [c] 11.0 | [d] 15.6 | 24.0 | 25.4 | 29.4 |
| Khojend | 2402-1 | do | Turkestan | (e) | [b] 15.7 | [c] 12.5 | [d] 13.3 | [d] 16.8 |
| Kisil | 2405 | do | do | [c] 8.2 | (e) | (e) | [b] 9.3 | |
| Koola | 2203 2 | do | Arabia | [c] 14.2 | [d] 12.0 | 25.8 | 24.2 | 33.2 |
| Kubanka | 1440 | Durum | Russia | 11.0 | 16.2 | 13.6 | 15.0 | |
| Do | 1516 | do | do | | | 16.0 | 21.5 | 18.0 |
| Do | 2246 | do | do | 7.0 | 12.0 | | | |
| Kurd | 2126-2 | do | Arabia | [c] 9.6 | [d] 10.0 | (e) | [b] 4.2 | [b] 14.6 |
| Little Club (Wash. No. 349). | 4066 | Club | Washington | 13.1 | 22.6 | 19.6 | 19.2 | 26.0 |
| Mahmoudi | 2099 | Durum | Algeria | 8.8 | 6.6 | | | |
| Do | 2099-1 | do | do | [c] 10.5 | [c] 9.8 | | | |
| Marouani | 1593 | do | do | 11.3 | 15.8 | | | |
| Do | 2235 | do | do | 8.3 | 14.5 | | | |
| Marquis | 4158 | Common | Canada | | | 22.1 | 22.5 | 23.1 |
| Pacific Bluestem | 4067 | do | Australia | 11.7 | 20.2 | 19.4 | 20.9 | 24.0 |
| Pelissier | 1584-1 | Durum | Algeria | (e) | [b] 10.9 | (e) | [c] 6.2 | [b] 16.6 |
| Do | 2086 | do | do | [b] 2.6 | [c] 9.0 | | | |
| Rebeiro | 2794 | Common | Portugal | [c] 4.8 | [d] 8.6 | | | |
| Richi | 2089 | Durum | Algeria | 9.3 | 18.5 | | | |
| Do | 2089-1 | do | do | [b] 10.4 | [c] 18.0 | | | |
| Rieti | 2793 | Common | Portugal | [c] 8.3 | [d] 14.0 | 21.3 | 19.0 | 24.9 |
| Rysting Fife | 3022-1 | do | Minnesota | (e) | [b] 18.7 | [c] 12.7 | [d] 5.0 | |
| Saragolla | 2228 | Durum | Italy | [c] 8.2 | [d] 12.7 | | | |
| Saumur | 2346-1 | Common | France | (e) | [b] 23.9 | [c] 16.0 | 23.0 | 22.7 |
| Sonora | 3036-2 | do | Mexico (?) | [b] 8.2 | [b] 34.4 | 15.5 | 20.5 | 24.7 |
| Do | 4074 | do | do | | 4.6 | 15.3 | 16.3 | |
| Talimka | 2495 | do | Turkestan | [c] 7.0 | [d] 14.6 | 27.5 | 23.0 | 25.9 |
| Urtoba | 2670 | do | Germany | (e) | [b] 18.7 | [c] 12.5 | [d] 8.0 | [b] 16.0 |
| Velvet Don | 2247 | Durum | Russia | 9.1 | 12.1 | | | |
| Do | 2247-1 | do | do | (e) | [b] 15.6 | [b] 14.6 | [c] 8.4 | |

[a] Acre yields are based on yields from single tenth-acre or duplicate twentieth-acre plats unless otherwise stated.

[b] Grown in rod rows, usually unreplicated.

[c] Grown in 2-rod rows replicated 2 to 4 times.

[d] Grown in single fortieth-acre plats.

[e] Grown in head rows, yield not recorded.

TABLE IX.—*Spring-wheat varieties tested at the Moro substation, showing the yields obtained in each year the variety was grown during the five years, 1911 to 1915, inclusive*—Contd.

| Variety. | C. I. No. | Division. | Origin. | Yield per acre (bushels).[a] | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1911 | 1912 | 1913 | 1914 | 1915 |
| Yantagbay | 2404-1 | Common | Russia | 9.6 | 19.0 | 21.3 | 19.2 | 25.2 |
| Yellow Gharnovka | 2096 | Durum | do | 7.8 | 16.6 | | | |
| Zacatecas | 2799-2 | Common | Mexico | [b] 4.8 | [b] 15.6 | 19.6 | 21.0 | 25.2 |
| Unnamed | 2083 | do | Hungary | [b] 7.8 | [c] 13.3 | | [d] 9.3 | [c] 9.4 |
| Do | 2500-1 | Durum | Algeria | [b] 10.6 | [c] 12.6 | | | |
| Do | 2545 | do | do | [b] 9.7 | [c] 9.3 | | | |
| Do | 2547-2 | do | Tunis | 7.3 | 12.8 | 17.1 | ([e]) | [d] 14.6 |
| Do | 2580 | Common | Germany | [b] 6.6 | [c] 9.8 | | | |
| Do | 2603 | do | Holland | [b] 8.7 | [c] 14.3 | ([e]) | [d] 7.2 | ([e]) |
| Do | 2607-1 | Durum | Rumania | [d] 8.3 | [b] 14.3 | ([e]) | [d] 2.1 | [d] 8.4 |
| Do | 2609-1 | do | do | [d] 11.4 | [b] 17.5 | ([e]) | [d] 5.2 | |
| Do | 2702 | Common | Italy | [b] 6.2 | [c] 6.6 | | | |
| Do | 2705 | do | do | [b] 8.8 | [c] 9.3 | | | |
| Do | 2796 | Durum | Mexico | ([e]) | [c] 15.4 | | | |
| Do | 2798 | Poulard | do | [b] 4.8 | [c] 6.0 | | | |
| Do | 2941 | Durum | Texas (?) | ([e]) | [b] 19.3 | [b] 10.3 | [c] 7.3 | [c] 14.9 |
| Do | 3035-2 | Club | Mexico | [d] 12.5 | [b] 25.0 | [b] 9.0 | | |
| Do | 4715 | Common | China | ([e]) | ([e]) | [d] 12.5 | Failure. | |
| Do | 4716 | do | do | ([e]) | ([e]) | [d] 15.2 | [d] 10.4 | [c] 12.0 |

[a] Acre yields are based on yields from single tenth-acre or duplicate twentieth-acre plats unless otherwise stated.

[b] Grown in 2-rod rows replicated 2 to 4 times.

[c] Grown in single fortieth-acre plats.

[d] Grown in rod rows, usually unreplicated.

[e] Grown in head rows, yield not recorded.

As the leading variety of spring wheat in the Columbia Basin is the Pacific Bluestem, this variety has always been grown on check plats. Table X presents a list of the spring-wheat varieties that have been grown three or more years, with yields expressed in percentages of the yield of the Bluestem variety. Where the varieties have been tested on areas smaller than one-twentieth of an acre, the average yield of the two highest yielding check plats or rows of the Pacific Bluestem was used as a basis of comparison. Where the test was on areas of one-twentieth acre or larger, the average yield of all Bluestem check plats was used. In all cases where the smaller areas were used, the Bluestem variety was sown in every fifth plat or row. It will be noted that certain varieties, like Koola, Karun, Early Baart, and Talimka, have given consistently higher yields than the Pacific Bluestem when grown in rows and in plats.

TABLE X.—*Yields of spring-wheat varieties grown at the Moro substation during three or more years, expressed in percentages of the average yield of the Pacific Bluestem variety grown in check plats and check rows.*

| Variety. | C. I. No. | Yields (percentage of the yield of Pacific Bluestem). | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1911 | 1912 | 1913 | 1914 | 1915 | Average. |
| Aulieata | 2407-2 | | [a] 200 | 119 | 109 | 85 | 128 |
| Bluestem. (See Pacific Bluestem.) | | | | | | | |
| Blé Noir | 2511 | 30 | 37 | 93 | 90 | 98 | 70 |
| Bobs | 2826-1 | | [a] 116 | [a] 110 | 118 | 106 | 112 |
| Bola Blanca | 2921-1 | | | [a] 89 | [b] 157 | [c] 165 | 137 |
| Chul | 2227-1 | | 127 | [a] 99 | 103 | 85 | 101 |
| Dale Gloria | 4155 | 33 | 43 | 94 | 87 | | 64 |
| Early Baart | 1697 | 124 | 94 | 129 | 124 | 111 | 116 |
| Elephant | 2824-1 | | [b] 82 | [a] 71 | [b] 40 | [b] 52 | 61 |
| Galgalos | 2398 | 70 | 61 | [a] 57 | | | 63 |
| Do | 2398-1 | | [a] 90 | [a] 56 | | [b] 54 | 67 |
| Ghirka Spring | 1517 | | | 101 | 77 | 109 | 96 |
| Glyndon (Minn. No. 163) | 2873 | 80 | 63 | 85 | | | 76 |

[a] Grown in 2-rod rows replicated 2 to 4 times.

[b] Grown in rod rows, usually unreplicated.

[c] Grown in single fortieth-acre plats.

TABLE X.—*Yields of spring-wheat varieties grown at the Moro substation during three or more years, expressed in percentages of the average yield of the Pacific Bluestem variety grown in check plats and check rows*—Continued.

| Variety. | C. I. No. | Yields (percentage of the yield of Pacific Bluestem). | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1911 | 1912 | 1913 | 1914 | 1915 | Average. |
| Heine Squarehead | 2669 | [a] 150 | [b] 146 | 111 | 108 | 98 | 123 |
| Hybrid No. 63 | 4157 | ....... | 76 | 106 | 71 | ....... | 84 |
| Hybrid No. 108 | 5025 | [a] 100 | 42 | [a] 96 | [b] 35 | ....... | 68 |
| Kahla | 2088-4 | ....... | [a] 50 | ....... | [c] 72 | [c] 30 | 51 |
| Karun | 2200-1 | [a] 164 | [b] 114 | 124 | 121 | 122 | 129 |
| Khojend | 2402-1 | ....... | [c] 112 | [a] 88 | [b] 133 | [b] 168 | 125 |
| Koola | 2203-2 | [a] 212 | [b] 88 | 133 | 116 | 134 | 136 |
| Kubanka | 1440,1516 | 94 | 80 | 84 | 103 | 75 | 87 |
| Kurd | 2126-2 | [a] 143 | [b] 73 | ....... | [c] 50 | [c] 56 | 80 |
| Little Club (Wash. No. 349) | 4066 | 114 | 108 | 100 | 91 | 108 | 104 |
| Marquis | 4158 | ....... | ....... | 114 | 108 | 96 | 106 |
| Pacific Bluestem | 4067 | 100 | 100 | 100 | 100 | 100 | 100 |
| Pelissier | 1584-1 | ....... | [c] 77 | ....... | [c] 73 | [c] 64 | 71 |
| Rieti | 2793 | [a] 124 | [b] 102 | 109 | 93 | 104 | 106 |
| Rysting Fife | 3022-1 | ....... | [c] 133 | [a] 90 | [b] 52 | ....... | 91 |
| Saumur | 2346-1 | ....... | [c] 170 | [a] 113 | 110 | 95 | 122 |
| Sonora | 3036-2 | ....... | [c] 242 | 80 | 98 | 103 | 131 |
| Do | 4074 | ....... | 23 | 79 | 80 | ....... | 66 |
| Talimka | 2495 | [a] 104 | [b] 106 | 141 | 110 | 108 | 114 |
| Urtoba | 2670 | ....... | [c] 133 | [a] 89 | [b] 84 | [c] 62 | 92 |
| Velvet Don | 2247-1 | ....... | [c] 111 | [c] 88 | [a] 98 | ....... | 99 |
| Yantagbay | 2404-1 | 84 | 94 | 109 | 93 | 105 | 97 |
| Zacatecas | 2799-2 | [a] 71 | [b] 77 | 101 | 100 | 105 | 91 |
| Unnamed | 2033 | [a] 117 | [a] 97 | ....... | [c] 108 | [a] 74 | 91 |
| Do | 2547-2 | 64 | 63 | 88 | ....... | [c] 56 | 68 |
| Do | 2603 | [a] 128 | [b] 104 | ....... | [c] 83 | ....... | 105 |
| Do | 2607 | ....... | [a] 90 | ....... | [c] 23 | [c] 32 | 48 |
| Do | 2941 | ....... | [a] 122 | [a] 80 | [b] 77 | [b] 149 | 107 |
| Do | 4716 | ....... | ....... | [c] 90 | [c] 112 | [b] 120 | 107 |

[a] Grown in 2-rod rows replicated 2 to 4 times.

[b] Grown in single fortieth-acre plats.

[c] Grown in rod rows, usually unreplicated.

Table XI gives the annual and average acre yields in bushels of the spring-wheat varieties that have been grown in twentieth-acre or larger plats during three or more years. The yields in 1911 and 1912 are for single tenth-acre plats. Those in the years from 1913 to 1915, inclusive, are the average yields of duplicate twentieth-acre plats.

TABLE XI.—*Annual and average yields of spring-wheat varieties grown at the Moro substation in twentieth-acre or larger plats for three or more years.*

| Variety. | C. I. No. | Yield per acre (bushels). | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1911 | 1912 | 1913 | 1914 | 1915 | Average. | |
| | | | | | | | 3-year. | 5-year. |
| Aulieata | 2407-2 | ...... | ...... | 23.0 | 22.9 | 20.2 | 22.0 | ...... |
| Blé Noir | 2511-2 | 3.5 | 7.5 | 18.0 | 18.3 | 23.6 | 20.0 | 14.2 |
| Chul | 2227-1 | 11.2 | 12.9 | [a] 22.3 | 21.5 | 20.2 | 21.3 | 17.6 |
| Early Baart | 1697 | 14.5 | 19.0 | 25.0 | 26.0 | 26.6 | 25.9 | 22.2 |
| Ghirka Spring | 1517 | ...... | ...... | 19.6 | 16.2 | 26.1 | 20.7 | ...... |
| Heine Squarehead | 2669-1 | ...... | ...... | 21.6 | 22.5 | 23.6 | 22.6 | ...... |
| Karun | 2200-1 | ...... | ...... | 24.0 | 25.4 | 29.4 | 26.3 | ...... |
| Koola | 2203-2 | ...... | ...... | 25.8 | 24.2 | 33.2 | 27.7 | ...... |
| Kubanka | 1440<br>1516 | 11.0 | 16.2 | 16.0 | 21.5 | 18.0 | 18.5 | 16.5 |
| Little Club | 4066 | 13.1 | 22.6 | 19.6 | 19.2 | 26.0 | 21.6 | 20.1 |
| Marquis | 4158 | ...... | ...... | 22.1 | 22.5 | 23.1 | 22.6 | ...... |
| Pacific Bluestem | 4067 | 11.7 | 20.2 | 19.4 | 20.9 | 24.0 | 21.4 | 19.2 |
| Sonora | 3036-2 | ...... | ...... | 15.5 | 20.5 | 24.7 | 20.2 | ...... |
| Talimka | 2495 | ...... | ...... | 27.5 | 23.0 | 25.9 | 25.5 | ...... |
| Yantagbay | 2404-1 | 9.6 | 19.0 | 21.3 | 19.4 | 25.2 | 22.0 | 18.9 |
| Zacatecas | 2799-2 | ...... | ...... | 19.6 | 21.0 | 25.2 | 21.9 | ...... |

[a] Yield estimated by comparison with yield of Aulieata in 1914 and 1915.

From Table XI it is seen that several varieties appear to be better than the Pacific Bluestem from the standpoint of yield. The Early Baart exceeded that variety during the five years by an average yield of 3 bushels per acre. The Koola variety exceeded the Bluestem in the 3-year average yield by 6.3 bushels per acre, and for the same period the Karun exceeded the Bluestem by 4.9 bushels per acre.

In Table XII the leading spring wheats grown at the Moro substation during 1913, 1914, and 1915 are arranged in several classes, showing the average yield for each variety and for each class.

**Table XII.**—*Kernel characters and 3-year average yields of leading varieties of spring wheat grown at the Moro substation in 1913, 1914, and 1915, arranged by classes, with the average yield per acre of each variety and of each class.*

| Class and variety. | C. I. No. | Character of kernels. | Average yield per acre in bushels, 1913 to 1915. |
|---|---|---|---|
| COMMON AND CLUB. | | | |
| Beardless: | | | |
| Pacific Bluestem | 4067 | Soft, white | 21.4 |
| Ghirka | 1517 | Soft, red | 20.7 |
| Karun | 2200-1 | Hard, white | 26.3 |
| Little Club | 4066 | Soft, white | 21.6 |
| Marquis | 4158 | Medium hard, red | 22.4 |
| Sonora | 3036-2 | Soft, white | 26.2 |
| Average | | | [illegible] |
| Bearded: | | | |
| Aulieata | 2407-2 | Hard, red | 22.3 |
| Chul | 2227-1 | .....do | 21.1 |
| Early Baart | 1697 | Soft, white | 25.9 |
| Heine Squarehead | 2669-1 | Soft, red | 22.6 |
| Koola | 2203-2 | Medium hard, red | 27.7 |
| Talimka | 2495 | Hard, amber | 25.5 |
| Yantagbay | 2404-1 | Hard, red | 22.0 |
| Zacatecas | 2799-2 | Soft, red | 21.4 |
| Average | | | [illegible] |
| DURUM. | | | |
| Blé Noir | 2511 | Hard, amber | [illegible] |
| Kubanka | 1516 | .....do | 18.5 |
| Average | | | [illegible] |

Table XII shows that the durum wheats apparently are not so well adapted to the Columbia Basin region as are the common and club varieties. The bearded varieties of common wheats exceeded the yield of the beardless common and club varieties by 1.7 bushels per acre, and the average yield of all common and club wheats exceeded the average yield of the two durum varieties by 3.5 bushels per acre.

## DESCRIPTIONS OF THE BEST VARIETIES.

The six varieties of spring wheat which have given the best average results are described and discussed below. Of these varieties, Pacific Bluestem and Little Club are well known and widely grown west of the Rocky Mountains. Early Baart is grown commercially to a small extent in Arizona and Washington, while Karun, Koola, and Talimka are new introductions not yet grown except in an experimental way. Heads of the six varieties are shown in figures 9 and 10.

*Pacific Bluestem.*—Pacific Bluestem (C. I. No. 4067) is the standard spring wheat on the farms of the Columbia Basin. It usually commands a premium of 3 to 4 cents a bushel over other varieties on western markets. It is a fairly early spring wheat of medium height, with beardless spikes (fig. 9, *B*), white, glabrous glumes, and midsized, soft, white kernels. In the West it is called simply "Bluestem," but it must not be confused with the Bluestems of the hard spring-wheat belt in the northern section of the Great Plains area or with the Bluestems of the Atlantic coast. The exact origin of this variety is not known, but almost certainly it is an Australian wheat. It closely resembles Rymer and Warren, two varieties from New South Wales. It is also identical with the White Australian, formerly widely grown in California.

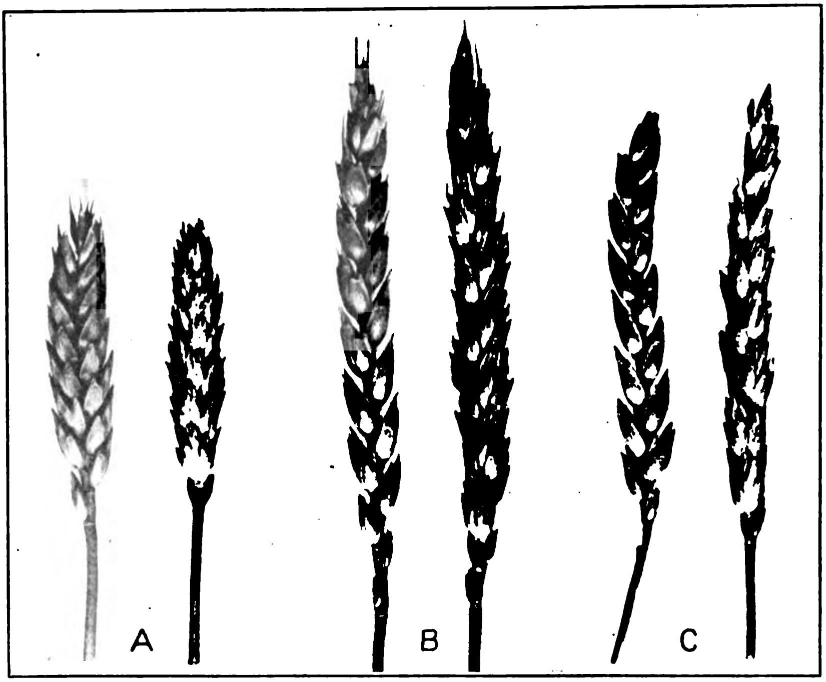

FIG. 9.—Heads of varieties of spring wheat grown at the Moro substation: *A*, Little Club; *B*, Pacific Bluestem; *C*, Karun.

*Little Club.*—Little Club (C. I. No. 4066) is the standard variety of club wheat in the western United States. It is a short, midseason to late variety, with very broad, short leaves. The beardless spikes are short, but broad and very compact, usually oblong in shape (fig. 9, *A*). The glumes are white and glabrous: the small kernels, white and soft.

The origin of this wheat is not known, but it is supposed to have been introduced into the United States from Mexico or some other portion of Latin America. In the experiments at Moro it has yielded as well or slightly better than Pacific Bluestem, but does not bring as high a price per bushel.

*Early Baart.*—Early Baart (C. I. No. 1697) is an early-maturing spring wheat, with a fairly short straw. The spikes are bearded (fig. 10, *A*), the glumes white and glabrous, and the kernels white, large, and soft. This variety was introduced into the United States from Australia by the United States Department of Agriculture in 1909. It has been grown to some extent in western Arizona for a number of years, but whether it was introduced into that State by the United States Department of Agriculture or was a separate introduction by some other agency is not known. It was brought to Washington from Arizona, and for this reason is sometimes called "Arizona Baart." It is now being grown commercially at several points in Adams and Lincoln Counties, Washington.

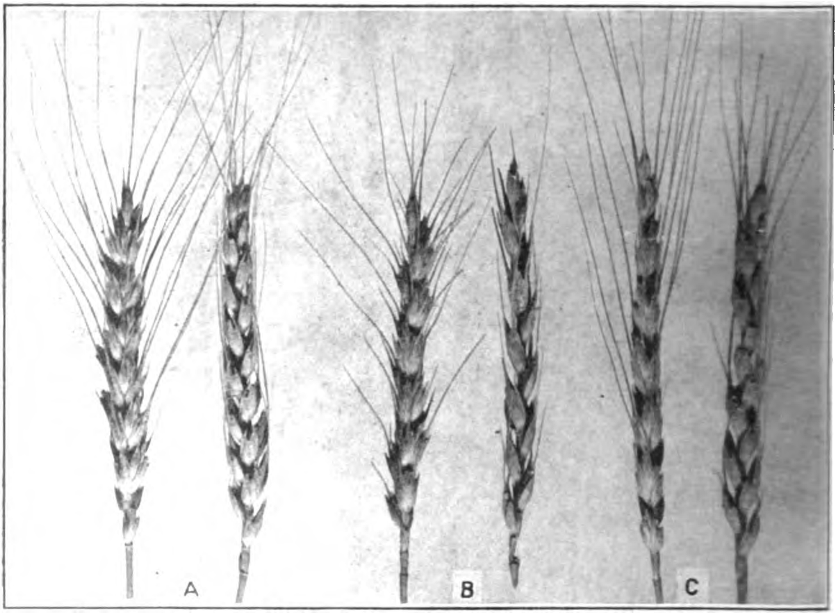

FIG. 10.—Heads of varieties of spring wheat grown at the Moro substation: *A*, Early Baart; *B*, Talimka; *C*, Koola.

At the Moro substation it has proved to be one of the best and earliest of the spring-wheat varieties. Being a soft wheat, it comes into competition with Pacific Bluestem, Little Club, and others of this class. The bearded heads are objectionable, because they do not pack well in the header boxes, but this disadvantage seems to be more than offset by the better yields obtained. The 5-year average yield of Early Baart has exceeded that of Pacific Bluestem by 3 bushels, while the 3-year average yield exceeds that of the Bluestem by 4.5 bushels per acre.

*Karun.*—Karun (C. I. No. 2200–1) is a rather dwarf and early-maturing spring wheat, with beardless spikes (fig. 9, *C*), white, glabrous glumes, and midsized, hard, amber-colored kernels. In yield it has ranked second among all the varieties of spring wheat grown at the Moro substation during the 3-year period, 1913 to 1915, inclusive. It has exceeded the Pacific Bluestem in that period by almost 5 bushels per acre. Karun resembles the Bluestem in its beardless, glabrous spikes, but differs particularly in its shorter straw and hard, amber-colored kernels. The original seed of Karun was obtained in Persia by the United States Department of Agriculture in 1902. The variety is not grown commercially, but only on the experimental plats.

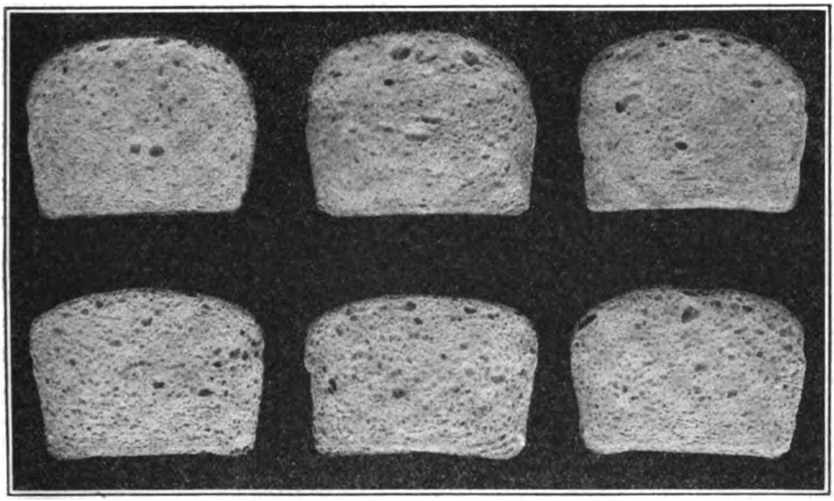

FIG. 11.—Cross sections of loaves of bread made from standard hard spring wheat and from varieties of spring wheat grown at the Moro substation. Left to right: Top row, standard, Marquis, and Bobs; bottom row, Saumur, Karun, and Early Baart.

*Koola.*—Koola (C. I. No. 2203–2) is a selection from a low-growing early variety of spring wheat, introduced into the United States from Arabia by the United States Department of Agriculture in 1902. It is a bearded variety (fig. 10, *C*), with white, glabrous glumes, and large, red, soft kernels. It has been tested on experiment farms for several years, but has never been distributed to growers. The Koola variety has given the highest average acre yield of all the spring wheats grown at the Eastern Oregon Dry-Farming Substation during the 3-year period, 1913 to 1915, inclusive. During that time it has outyielded the Pacific Bluestem by 6.3 bushels per acre. It also has proved superior to Pacific Bluestem in milling value during that period.

*Talimka.*—Talimka (C. I. No. 2495) is an early-maturing, low-growing, bearded spring wheat (fig. 10, *B*), with white, glabrous glumes, and large, flinty, hard, amber kernels. The kernels of this rare variety and of related varieties are so large and so hard that some of them were mistaken for varieties of durum wheat when first introduced. The Talimka variety was obtained in 1904 by a representative of the United States Department of Agriculture at Askabad, Russian Turkestan, where other similar varieties and the closely related varieties of the Chul group are commonly grown also.

At the Moro substation the Talimka variety has proved one of the best yielding of the spring wheats. In a 3-year period, 1913–1915, inclusive, its yield has exceeded that of Pacific Bluestem by slightly more than 4 bushels. So far it is grown only in an experimental way.

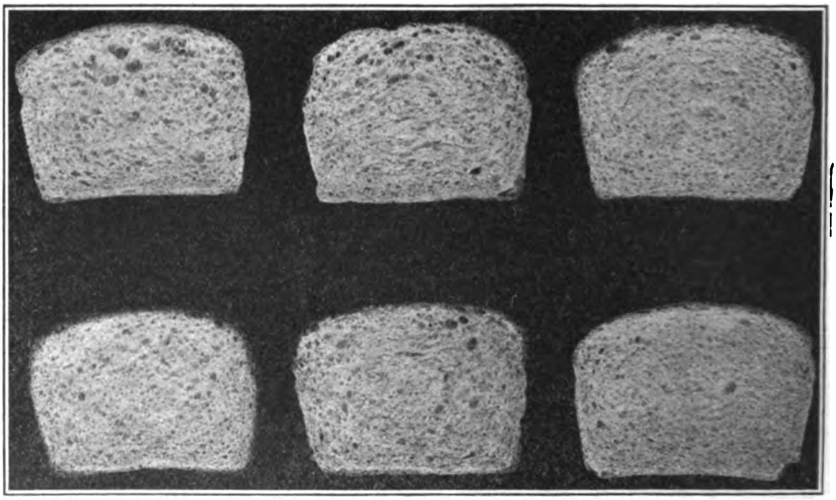

FIG. 12.—Cross sections of loaves of bread made from varieties of hard spring wheat grown at the Moro substation. Left to right: Top row, Koola, Pacific Bluestem, and Chul; bottom row, Yantagbay, Aulieata, and Talimka.

MILLING AND BAKING EXPERIMENTS.

To ascertain the relative milling and baking values of the spring wheats grown at the substation, tests of several varieties have been made by the Plant Chemical Laboratory of the Bureau of Chemistry. Table XIII gives the data obtained from analyses of the wheats and of flour milled therefrom. Figures 11 and 12 show loaves of bread made from flour milled from spring-wheat varieties grown at the Moro substation in 1915. The loaf labeled "Standard" is from flour milled from one of the hard spring wheats of the northern Great Plains. All the wheats grown at Moro were milled from four to five months after harvest, and the flour was made into bread about two weeks after milling. Miss H. L. Wessling, of the Plant Chemical Laboratory, conducted the baking experiments.

It will be observed from the analyses and photographs of loaves that all of the varieties appear to be equally as good as, and most of them better than, the Pacific Bluestem, which is the standard spring wheat of the Columbia Basin. All the samples from which the flour was made were from the varietal plats and therefore were grown under similar conditions.

TABLE XIII.—*Characteristics of grain and of flours from spring wheats grown at the Moro substation in 1913, 1914, and 1915.*

KERNEL CHARACTERS, CHEMICAL ANALYSES, KERNEL WEIGHTS, AND BUSHEL WEIGHTS OF THE GRAIN.

| Variety. | C. I. No. | Kernel color. | Water. | Ash. | Nitrogen. | Protein (N×5.7). | Alcohol-soluble nitrogen. | Weight. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 1,000 kernels. | Bushel. |
| GROWN IN 1913. | | | | | | | | | |
| *Kernel soft.* | | | | | | | | | |
| Beardless: | | | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Grams.* | *Pounds.* |
| Pacific Bluestem | 4067 | White | 7.62 | 1.73 | 2.39 | 13.62 | 1.04 | 28.4 | 57.4 |
| Bearded: | | | | | | | | | |
| Heine Squarehead | 2669 | Red | 7.61 | 1.80 | 2.51 | 14.31 | 1.19 | 24.6 | 55.5 |
| Rieti | 2793 | ...do | 7.74 | 1.99 | 2.54 | 14.48 | 1.22 | 28.4 | 55.0 |
| Koola | 2203-2 | ...do | 8.00 | 1.92 | 2.52 | 14.37 | 1.11 | 31.3 | 56.4 |
| *Kernel hard.* | | | | | | | | | |
| Beardless: | | | | | | | | | |
| Marquis | 4158 | ...do | 7.83 | 1.80 | 2.44 | 13.91 | 1.03 | 21.7 | 55.5 |
| Karun | 2200-1 | Amber | 8.39 | 1.59 | 2.36 | 13.45 | .99 | 32.9 | 55.7 |
| Bearded: | | | | | | | | | |
| Aulieata | 2407-2-1 | Red | 8.06 | 1.70 | 2.41 | 13.74 | 1.01 | 34.3 | 58.3 |
| Yantagbay | 2404-1-1 | ...do | 8.06 | 1.47 | 2.25 | 12.83 | .94 | 30.5 | 57.2 |
| Talimka | 2495-1 | Amber | 8.25 | 1.55 | 2.34 | 13.34 | 1.00 | 31.4 | 56.5 |
| GROWN IN 1914. | | | | | | | | | |
| *Kernel soft.* | | | | | | | | | |
| Beardless: | | | | | | | | | |
| Pacific Bluestem | 4067 | White | 8.66 | 2.54 | 3.34 | 19.04 | 1.38 | 25.7 | 55.0 |
| Bobs | 2826 | ...do | 9.04 | 1.91 | 2.98 | 16.98 | 1.25 | 26.7 | 58.7 |
| Bearded: | | | | | | | | | |
| Early Baart | 1697 | ...do | 8.05 | 1.92 | 2.86 | 16.30 | 1.11 | 25.0 | 60.8 |
| Heine Squarehead | 2669 | Red | 8.72 | 2.04 | 3.13 | 17.84 | 1.42 | 27.8 | 56.4 |
| Rieti | 2793 | ...do | 8.69 | 1.93 | 3.41 | 19.44 | 1.50 | 26.6 | 58.6 |
| Koola | 2203-2 | ...do | 8.51 | 1.99 | 2.97 | 16.93 | 1.28 | 26.8 | 55.7 |
| *Kernel hard.* | | | | | | | | | |
| Beardless: | | | | | | | | | |
| Marquis | 4158 | ...do | 8.24 | 2.10 | 3.26 | 18.58 | ...... | 22.6 | 55.7 |
| Karun | 2200-1 | Amber | 8.32 | 1.74 | 2.68 | 15.28 | 1.16 | 27.5 | 61.2 |
| Bearded: | | | | | | | | | |
| Aulieata | 2407-2-1 | Red | 8.32 | 1.83 | 2.87 | 16.36 | 1.12 | 35.3 | 59.7 |
| Chul | 2227 | ...do | 8.16 | 1.87 | 2.95 | 16.81 | 1.14 | 28.6 | 55.0 |
| Yantagbay | 2404-1-1 | ...do | 7.92 | 1.79 | 2.91 | 16.59 | 1.14 | 31.2 | 56.4 |
| Saumur | 2346 | Amber | 8.61 | 1.98 | 3.02 | 17.21 | 1.18 | 19.8 | 54.9 |
| Talimka | 2495-1 | ...do | 8.24 | 1.89 | 2.97 | 16.93 | 1.23 | 27.3 | 56.8 |
| GROWN IN 1915. | | | | | | | | | |
| *Kernel soft.* | | | | | | | | | |
| Beardless: | | | | | | | | | |
| Pacific Bluestem | 4067 | White | 6.50 | 1.86 | 2.68 | 15.30 | ...... | 26.7 | 52.8 |
| Bobs | 2826-1 | ...do | 8.52 | 1.72 | 2.80 | 15.95 | ...... | 27.6 | 60.3 |
| Bearded: | | | | | | | | | |
| Early Baart | 1697 | ...do | 8.42 | 1.95 | 2.60 | 14.80 | ...... | 28.7 | 59.4 |
| Koola | 2203-2 | Red | 8.60 | 2.14 | 2.97 | 16.90 | ...... | 24.3 | 52.5 |

TABLE XIII.—*Characteristics of grain and of flours from spring wheats grown at the Moro substation in 1913, 1914, and 1915*—Continued.

KERNEL CHARACTERS, CHEMICAL ANALYSES, KERNEL WEIGHTS, AND BUSHEL WEIGHTS OF THE GRAIN—Continued.

| Variety. | C. I. No. | Kernel color. | Water. | Ash. | Nitrogen. | Protein (N× 5.7). | Alcohol-soluble nitrogen. | Weight: 1,000 kernels. | Weight: Bushel. |
|---|---|---|---|---|---|---|---|---|---|
| GROWN IN 1915—Continued. | | | | | | | | | |
| *Kernel hard.* | | | | | | | | | |
| Beardless: | | | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Per ct.* | *Grams.* | *Pounds.* |
| Marquis | 4158 | Red | 8.23 | 2.42 | 3.26 | 18.60 | ....... | 16.0 | [illegible] |
| Karun | 2200-1 | Amber | 8.46 | 1.58 | 2.67 | 15.20 | ....... | 24.5 | [illegible] |
| Bearded: | | | | | | | | | |
| Aulieata | 2407-2-1 | Red | 6.61 | 2.12 | 2.95 | 16.80 | ....... | 27.2 | [illegible] |
| Chul | 2227-1 | ...do | 6.67 | 1.89 | 2.81 | 16.00 | ....... | 24.5 | [illegible] |
| Yantagbay | 2404-1 | ...do | 7.00 | 1.99 | 2.85 | 16.25 | ....... | 29.2 | [illegible] |
| Saumur | 2346-1 | Amber | 8.16 | 2.07 | 2.97 | 16.90 | ....... | 20.6 | [illegible] |
| Talimka | 2495-1 | ...do | 6.74 | 1.98 | 2.97 | 16.90 | ....... | 26.7 | [illegible] |
| AVERAGES. | | | | | | | | | |
| *Kernel soft.* | | | | | | | | | |
| Beardless: | | | | | | | | | |
| Pacific Bluestem | 4067 | White | 7.59 | 2.05 | 2.80 | 15.99 | ....... | 26.9 | [illegible] |
| Bobs [a] | 2826 | ...do | 8.78 | 1.82 | 2.89 | 16.47 | ....... | 27.2 | [illegible] |
| Bearded: | | | | | | | | | |
| Early Baart [a] | 1697 | ...do | 8.24 | 1.94 | 2.73 | 15.55 | ....... | 26.9 | [illegible] |
| Heine Squarehead [a] | 2669 | Red | 8.17 | 1.92 | 2.82 | 16.08 | ....... | 26.2 | [illegible] |
| Rieti [a] | 2793 | ...do | 8.22 | 1.96 | 2.98 | 16.96 | ....... | 28.5 | [illegible] |
| Koola | 2203-2 | ...do | 8.37 | 2.02 | 2.82 | 16.07 | ....... | 27.5 | [illegible] |
| *Kernel hard.* | | | | | | | | | |
| Beardless: | | | | | | | | | |
| Marquis | 4158 | ...do | 8.10 | 2.11 | 2.99 | 17.03 | ....... | 20.1 | [illegible] |
| Karun | 2200-1 | Amber | 8.39 | 1.64 | 2.57 | 14.64 | ....... | 26.3 | [illegible] |
| Bearded: | | | | | | | | | |
| Aulieata | 2407-2-1 | Red | 7.66 | 1.88 | 2.74 | 15.93 | ....... | 32.3 | [illegible] |
| Chul [a] | 2227 | ...do | 7.47 | 1.88 | 2.88 | 16.41 | ....... | 33.1 | [illegible] |
| Yantagbay | 2404-1-1 | ...do | 7.66 | 1.75 | 2.67 | 15.22 | ....... | 30.3 | [illegible] |
| Saumur [a] | 2346 | Amber | 8.39 | 2.03 | 3.00 | 17.06 | ....... | 20.2 | [illegible] |
| Talimka | 2495-1 | ...do | 7.74 | 1.81 | 2.76 | 15.72 | ....... | 28.5 | [illegible] |

CHEMICAL ANALYSES AND BAKING QUALITIES OF THE FLOUR.

| Variety. | Cereal Investigations No. | Water. | Ash. | Nitrogen. | Water-soluble nitrogen. | Alcohol-soluble nitrogen. | Protein (N × 5.7). | 100 grams of flour: Water absorbed. | 100 grams of flour: Maximum expansion. | Loaf: Color.[b] | Loaf: Texture. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grown in 1913: | | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *C. c.* | *C. c.* | *P. ct.* | *P. ct.* |
| Pacific Bluestem | 4067 | 11.83 | 0.448 | 1.90 | 0.295 | 1.05 | 10.83 | 64.5 | 400 | c94 | [illegible] |
| Heine Squarehead | 2669 | 11.83 | .516 | 2.17 | .203 | 1.25 | 12.37 | 69.0 | 445 | c93 | [illegible] |
| Rieti | 2793 | 11.72 | .548 | 2.19 | .267 | 1.29 | 12.48 | 67.5 | 550 | c93 | [illegible] |
| Koola | 2203-2 | 11.80 | .464 | 2.07 | .203 | 1.09 | 11.80 | 69.0 | 400 | 95 | [illegible] |
| Marquis | 4158 | 11.78 | .396 | 2.20 | .267 | 1.12 | 12.54 | 71.0 | 660 | 96 | [illegible] |
| Karun | 2200-1 | 11.55 | .428 | 2.07 | .160 | 1.20 | 11.80 | 74.5 | 585 | c95 | [illegible] |
| Aulieata | 2407-2-1 | 11.79 | .400 | 2.07 | .204 | 1.12 | 11.80 | 73.7 | 590 | 95 | [illegible] |
| Yantagbay | 2404-1-1 | 11.69 | .392 | 1.98 | .246 | 1.07 | 11.29 | 71.8 | 620 | c96 | [illegible] |
| Talimka | 2495-1 | 11.81 | .428 | 2.07 | .154 | 1.10 | 11.80 | 72.5 | 580 | c95 | [illegible] |
| Standard | ....... | ....... | ....... | ....... | ....... | ....... | 11.05 | 71.5 | 810 | 97 | [illegible] |
| Grown in 1914: | | | | | | | | | | | |
| Pacific Bluestem | 4067 | 10.53 | .580 | 2.57 | .337 | .751 | 14.65 | 67.0 | 380 | g93 | [illegible] |
| Bobs | 2826 | 10.91 | .490 | 2.72 | .390 | .730 | 15.50 | 67.0 | 620 | 99 | [illegible] |
| Early Baart | 1697 | 11.29 | .570 | 2.27 | .358 | .596 | 12.94 | 62.0 | 585 | g94 | [illegible] |
| Heine Squarehead | 2669 | 10.96 | .550 | 2.72 | .347 | .826 | 15.50 | 65.0 | 480 | g94½ | [illegible] |
| Rieti | 2793 | 10.76 | .510 | 3.05 | .386 | .870 | 17.39 | 68.0 | 420 | g93½ | [illegible] |
| Koola | 2203-2 | 12.06 | .590 | 2.54 | .372 | .709 | 14.48 | 65.0 | 405 | g92 | [illegible] |

[a] Data for 2 years only.

[b] Abbreviations: c=creamy, vc=very creamy, g=gray.

[c] Stiff.

[d] Spongy.

TABLE XIII.—*Characteristics of grain and of flours from spring wheats grown at the Moro substation in 1913, 1914, and 1915*—Continued.

CHEMICAL ANALYSES AND BAKING QUALITIES OF THE FLOUR—Continued.

| Variety. | Cereal Investigations No. | Water. | Ash. | Nitrogen. | Water-soluble nitrogen. | Alcohol-soluble nitrogen. | Protein (N × 5.7). | 100 grams of flour. Water absorbed. | 100 grams of flour. Maximum expansion. | Loaf. Color.[a] | Loaf. Texture. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grown in 1914—Continued. | | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *C. c.* | *C. c.* | *P. ct.* | *P. ct.* |
| Marquis | 4158 | 10.25 | 0.590 | 2.61 | 0.358 | 0.793 | 14.88 | 69.0 | 585 | 96 | 96½ |
| Karun | 2200-1 | 11.43 | .530 | 2.36 | .281 | .681 | 13.45 | 68.0 | 580 | c97 | 96 |
| Aulieata | 2407-2-1 | 10.83 | .580 | 2.55 | .302 | .702 | 14.54 | 70.0 | 620 | 96 | 96 |
| Chul | 2227 | 11.48 | .470 | 2.53 | .323 | .667 | 14.42 | 68.0 | 580 | c96 | 98 |
| Yantagbay | 2404-1-1 | 12.31 | .440 | 2.54 | .309 | .681 | 14.48 | 69.0 | 565 | 96 | 96 |
| Saumur | 2346 | 11.97 | .500 | 2.61 | .338 | .737 | 14.88 | 70.0 | 555 | c95 | 92 |
| Talimka | 2495-1 | 10.78 | .490 | 2.61 | .344 | .716 | 14.88 | 70.0 | 595 | c97 | 97 |
| Standard | ...... | 11.75 | .410 | 2.08 | .347 | .582 | 11.86 | 65.0 | 840 | c98 | 98 |
| Grown in 1915: | | | | | | | | | | | |
| Pacific Bluestem | 4067 | 12.51 | .436 | 2.17 | ...... | ...... | 12.37 | 64.0 | 470 | 97½ | 96 |
| Bobs | 2826-1 | 12.05 | .403 | 2.44 | ...... | ...... | 13.90 | 66.4 | 590 | c98 | 97 |
| Early Baart | 1697 | 11.14 | .489 | 2.27 | ...... | ...... | 12.94 | 66.0 | 500 | c97 | 95 |
| Koola | 2203-2 | 11.28 | .474 | 2.51 | ...... | ...... | 14.30 | 69.0 | 510 | 96 | 95 |
| Marquis | 4158 | 11.39 | .490 | 2.77 | ...... | ...... | 15.80 | 68.0 | 610 | g97 | 97 |
| Karun | 2200-1 | 11.50 | .456 | 2.34 | ...... | ...... | 13.35 | 65.5 | 520 | vc97 | 94 |
| Aulieata | 2407-2-1 | 12.66 | .483 | 2.52 | ...... | ...... | 14.36 | 68.0 | 660 | c96 | 96½ |
| Chul | 2227-1 | 12.12 | .466 | 2.46 | ...... | ...... | 14.00 | 67.0 | 610 | c96 | 97 |
| Yantagbay | 2404-1 | 12.49 | .428 | 2.42 | ...... | ...... | 13.80 | 69.0 | 600 | c96 | 96½ |
| Saumur | 2346-1 | 11.12 | .481 | 2.60 | ...... | ...... | 14.82 | 69.0 | 580 | vc97 | 94 |
| Talimka | 2495-1 | 11.78 | .420 | 2.47 | ...... | ...... | 14.08 | 67.0 | 610 | c97 | 97 |
| Standard | ...... | ...... | ...... | ...... | ...... | ...... | 10.43 | 66.0 | 840 | c98 | 99 |
| Average: | | | | | | | | | | | |
| Pacific Bluestem | 4067 | 11.62 | .488 | 2.21 | ...... | ...... | 12.62 | 65.2 | 417 | 94.8 | 93.0 |
| Bobs [b] | 2826 | 11.48 | .447 | 2.58 | ...... | ...... | 14.70 | 66.7 | 605 | 98.5 | 97.5 |
| Early Baart [b] | 1697 | 11.22 | .530 | 2.27 | ...... | ...... | 12.89 | 64.0 | 543 | 95.5 | 96.5 |
| Heine Squarehead [b] | 2669 | 11.40 | .533 | 2.45 | ...... | ...... | 13.94 | 67.0 | 463 | 93.8 | 92.0 |
| Rieti [b] | 2793 | 11.24 | .544 | 2.62 | ...... | ...... | 14.97 | 67.8 | 485 | 92.8 | 89.0 |
| Koola | 2203-2 | 11.75 | .443 | 2.37 | ...... | ...... | 13.53 | 68.0 | 438 | 94.0 | 92.0 |
| Marquis | 4158 | 11.14 | .492 | 2.53 | ...... | ...... | 14.41 | 69.0 | 618 | 96.0 | 96.5 |
| Karun | 2200-1 | 11.49 | .471 | 2.26 | ...... | ...... | 12.87 | 69.3 | 562 | 96.3 | 94.3 |
| Aulieata | 2407-2-1 | 11.76 | .488 | 2.38 | ...... | ...... | 13.57 | 70.6 | 623 | 96.6 | 95.1 |
| Chul [b] | 2227 | 11.80 | .468 | 2.50 | ...... | ...... | 14.21 | 67.5 | 595 | 96.0 | 97.5 |
| Yantagbay | 2404-1-1 | 12.16 | .420 | 2.31 | ...... | ...... | 13.19 | 69.9 | 595 | 96.0 | 95.5 |
| Saumur [b] | 2346 | 11.55 | .491 | 2.605 | ...... | ...... | 14.85 | 69.5 | 568 | 96.0 | 93.0 |
| Talimka | 2495-1 | 11.46 | .446 | 2.38 | ...... | ...... | 13.59 | 69.8 | 595 | 96.3 | 95.6 |
| Standard | ...... | [c] 11.75 | [c] .410 | [c] 2.08 | ...... | ...... | 11.11 | 67.5 | 830 | 97.6 | 98.3 |

[a] Abbreviations: c=creamy, vc=very creamy, g=gray.

[b] Average data for 2 years only.

[c] Data for 1 year only.

### RATE-OF-SEEDING AND DATE-OF-SEEDING EXPERIMENTS.

During the years 1912 to 1915, inclusive, rate-of-seeding and date- -seeding experiments with spring wheat were conducted with the acific Bluestem variety. This wheat was sown at rates varying om 2 to 8 pecks per acre on each of two dates, one early and one te in the spring. Unreplicated tenth-acre plats were used, except 1915, when all seedings were made on duplicate twentieth-acre ats. The 8-peck rate was omitted in 1912 and the 2-peck rate 1915. Table XIV gives the yields obtained in each year, the erage yield from each rate on both dates and on each date in all ars, and the average yield of all rates from each date.

Table XIV shows that there is little difference in the average yield r acre from the different rates of seeding during the four years. The ly seeding, however, gave much higher yields than the later seed- in every year except 1912. The average increase in yield from the early seeding in the four years was 6.2 bushels per acre. In the early seeding the thickest rate (8 pecks) gave the highest average yield, and in the late seeding the 3-peck rate gave the highest average yield. The average date of the early seeding was March 22 and of the late seeding, April 20.

TABLE XIV.—*Annual and average yields obtained in a rate-of-seeding test of Pacific Bluestem wheat sown on two dates at the Moro substation during the 4-year period, 1912 to 1915, inclusive.*

| Year and date of seeding. | Yields per acre (bushels) at given rates of seeding. | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 pecks. | 3 pecks. | 4 pecks. | 5 pecks. | 6 pecks. | 7 pecks. | 8 pecks. | Average. |
| Season of 1912: | | | | | | | | |
| Early (Mar. 25) | 7.0 | 8.8 | 13.6 | 12.5 | 10.5 | 13.1 | ........ | 10.9 |
| Late (Apr. 26) | 7.8 | 15.5 | 11.8 | 14.0 | 15.1 | 15.5 | ........ | 13.3 |
| Season of 1913: | | | | | | | | |
| Early (Mar. 25) | 18.5 | 17.5 | 20.8 | 21.3 | 18.3 | 20.0 | 20.0 | 19.5 |
| Late (Apr. 25) | 10.5 | 10.0 | 7.7 | 7.6 | 8.3 | 10.4 | 13.1 | 9.7 |
| Season of 1914: | | | | | | | | |
| Early (Mar. 16) | 17.5 | 15.5 | 14.5 | 17.8 | 16.3 | 17.3 | 18.1 | 16.7 |
| Late (Apr. 16) | 13.7 | 11.7 | 8.7 | 5.3 | 3.7 | 4.0 | 3.7 | 7.3 |
| Season of 1915: | | | | | | | | |
| Early (Mar. 22) | ........ | 18.6 | 15.1 | 17.2 | 20.6 | 18.0 | 19.2 | 18.1 |
| Late (Apr. 15) | ........ | 10.4 | 11.1 | 10.5 | 11.4 | 12.8 | 10.2 | 11.1 |
| Average yields: | | | | | | | | |
| All dates | 12.5 | 13.5 | 12.9 | 13.3 | 13.3 | 13.9 | 14.0 | ........ |
| Early seeding | 14.3 | 15.1 | 16.0 | 17.2 | 16.4 | 17.1 | 19.1 | 16.3 |
| Late seeding | 10.6 | 11.9 | 9.8 | 9.4 | 9.6 | 10.7 | 9.0 | 10.1 |

On April 9, 1913, and April 6, 1914, eight check plats were sown with the same variety, Pacific Bluestem, at the rate of 5 pecks per acre. This provided a medium date of seeding to compare with the early and late dates discussed above. The earliest seeding at the rate of 5 pecks per acre gave higher yields in both years than any check plat, further indicating the advantage of early seeding.

## SPRING OATS.

From the standpoint of total production, oats are a less important crop than wheat and barley in the Columbia Basin. Judging from yields obtained at the substation at Moro, oats probably have not received the attention they deserve from the farmers of this section. This undoubtedly is due to the fact that the header and the combined harvester-thrasher, the harvesting machines most commonly used in the Columbia Basin, are not adapted to the economical handling of this crop. Grain must be thoroughly ripe before it is cut with a header or thrashed with a combined harvester-thrasher. Much of the oat crop is lost through shattering if left too long after maturity before it is harvested. The oat varieties at the substation have always been cut with a binder and thrashed from the shock.

### VARIETAL EXPERIMENTS.

In 1912 the oat varietal experiment was on spring-disked corn ground. In the other years reported the oats were grown on ground summer tilled the previous year, as in the case of the spring barley and wheat.

The results of the test of oat varieties that have been grown for two or more years are presented in Table XV, with the annual yield in bushels per acre produced by each.

TABLE XV.—*Annual yields of 20 varieties and strains of spring oats grown in field plats at the Moro substation during two or more years in the 5-year period, 1911 to 1915, inclusive.*

| Variety. | C. I. No. | Period of maturity. | Yield per acre (bushels). | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1911 | 1912 | 1913 | 1914 | 1915 |
| Banner | 160 | Midseason | 17.1 | 38.4 | 36.3 | ...... | ...... |
| Black American | 549 | .....do | 35.1 | 35.1 | 42.5 | 33.8 | 43.3 |
| Canadian | 444 | .....do | 17.1 | 38.4 | 46.4 | 45.2 | 48.9 |
| Danish Island | 519 | .....do | ...... | ...... | ...... | 33.1 | 49.0 |
| Kherson | 459 | Early | 28.9 | 39.6 | 43.6 | 54.2 | 52.6 |
| Shadeland Challenge | 680 | Late | ...... | 17.3 | 31.2 | ...... | ...... |
| Shadeland Climax | 681 | Midseason | ...... | 44.3 | 36.5 | 35.1 | 55.3 |
| Siberian | 635 | .....do | 30.8 | 35.6 | 53.7 | 37.0 | 58.3 |
| Sixty-Day | 165 | Early | 18.7 | 40.0 | 47.8 | 52.3 | 57.8 |
| Sixty-Day 4 P4 | 789 | .....do | 11.2 | 37.1 | 66.5 | 33.7 | ...... |
| Sixty-Day selection | 165-1 | .....do | ...... | ...... | ...... | 65.6 | 57.2 |
| Do | 165-1-1 | .....do | | ...... | 45.6 | 61.9 | 57.1 |
| Do.[a] | 165 | .....do | ...... | 27.8 | 47.2 | ...... | ...... |
| Storm King | 522-1 | Midseason | | ...... | 46.2 | 35.6 | 63.0 |
| Swedish Select | 134 | .....do | 13.5 | 37.0 | 40.7 | 37.2 | 47.0 |
| Swedish Select selection | 134-1 | .....do | ...... | ...... | 40.6 | 37.9 | 52.0 |
| Tartar King | 523 | .....do | ...... | ...... | 29.4 | 35.0 | ...... |
| White Russian | 636 | Late | 13.7 | 28.1 | 30.0 | ...... | ...... |
| Local variety[b] | 795 | Midseason | 14.3 | ...... | 44.1 | 38.4 | 51.4 |
| Unnamed | 357-1 | .....do | ...... | ...... | ...... | 45.0 | 49.2 |

[a] Selection from the branch experiment station, Union, Oreg.
[b] An unnamed variety grown locally; similar to Siberian.

## DESCRIPTIONS OF THE BEST VARIETIES.

Table XVI shows the 3-year and 5-year average yields of 11 of the more important varieties and gives certain other data regarding these varieties. This table shows that the 5-year average yield of the Kherson is highest, though there is little difference in the 5-year average yield of the Kherson and that of the Sixty-Day and Siberian. In the 3-year average, the Sixty-Day and a selection from Sixty-Day show the highest yields.

TABLE XVI.—*Agronomic data and 3-year and 5-year average yields for the 11 most important varieties and selections of spring oats tested at the Moro substation during three or more years in the 5-year period, 1911 to 1915, inclusive.*

| Variety. | C. I. No. | Date headed. | Date ripe. | Height. | Bushel weight. | Average yield per acre. | |
|---|---|---|---|---|---|---|---|
| | | | | | | 3 years. | 5 years. |
| | | | | *Inches.* | *Pounds.* | *Bushels.* | *Bushels.* |
| Sixty-Day selection | 165-1-1 | June 16 | July 9 | 28 | 30.7 | 54.9 | ........ |
| Kherson | 459 | June 18 | July 13 | 26 | 30.0 | 50.1 | 43.8 |
| Sixty-Day | 165 | ...do.... | July 12 | 26 | 30.7 | 52.6 | 43.3 |
| Siberian | 635 | June 27 | July 20 | 34 | 34.0 | 49.7 | 43.1 |
| Storm King selection | 522-1 | ...do.... | July 18 | 33 | 33.0 | 48.3 | ........ |
| Canadian | 444 | June 26 | ...do.... | 33 | 36.5 | 46.8 | 39.2 |
| Local variety | 795 | June 29 | July 20 | 32 | 28.4 | 44.6 | ........ |
| Swedish Select selection | 134-1 | June 26 | July 18 | 33 | 32.4 | 43.5 | ........ |
| Shadeland Climax | 681 | July 1 | July 21 | 32 | 33.3 | 42.3 | ........ |
| Black American | 549 | June 28 | ...do.... | 28 | 28.6 | 39.9 | 38.0 |
| Swedish Select | 134 | June 26 | July 20 | 32 | 32.7 | 41.6 | 35.1 |

*Kherson and Sixty-Day.*—The Kherson and Sixty-Day are very similar varieties of oats which came originally from southern Russia. The Kherson was introduced about 20 years ago from the Kherson Government, and the Sixty-Day about 15 years ago from the Podolia Government. These oats are both early in maturing, ripening at Moro about the second week in July. The straw is slender and

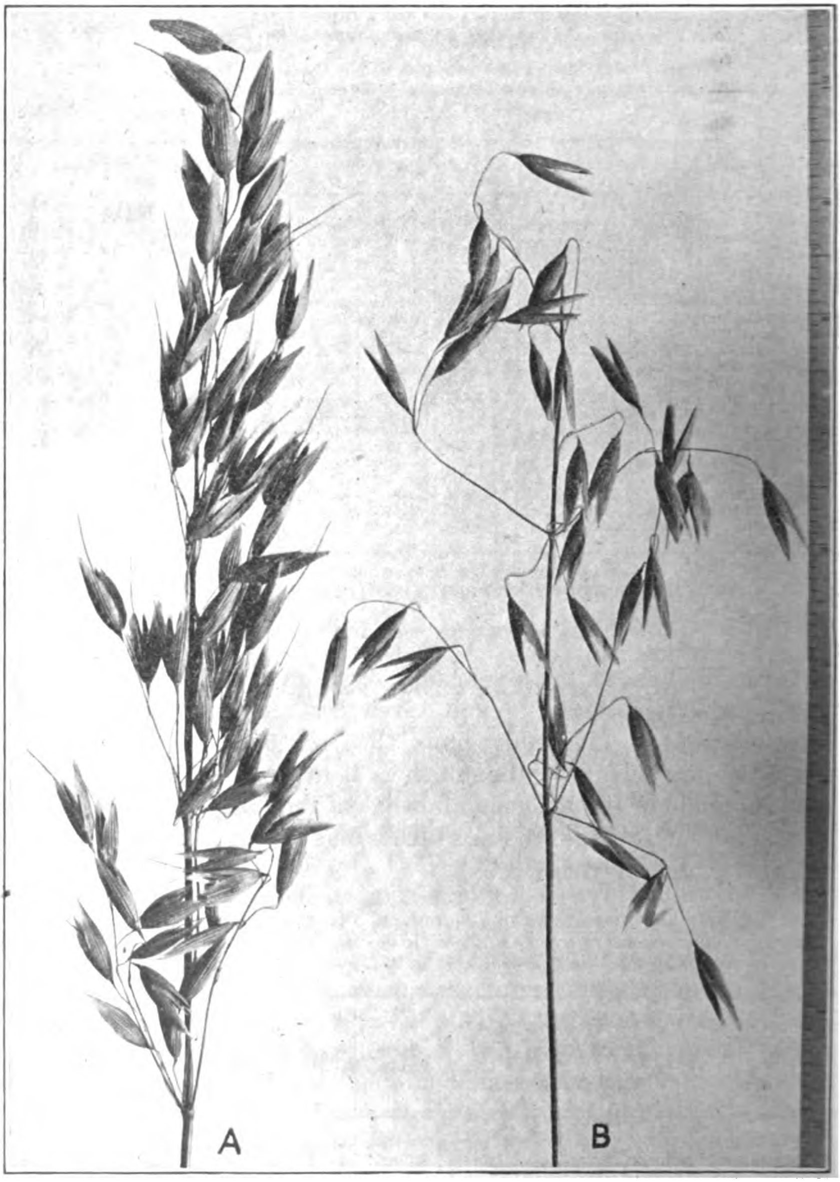

FIG. 13.—Heads of oats grown at the **Moro substation: *A*, Swedish Select, *B*, Kherson.**

usually rather short. The heads are small, spreading (fig. 13), and usually well filled with slender, yellow kernels. While the weight per bushel is sometimes rather low, the percentage of hull is lower than in most varieties of oats. The Sixty-Day selection which has given the highest 3-year average yield at Moro does not differ in appearance from the unselected variety. The principal objections to these early oats are the small size of the kernel and the shortness of the straw. Because of the short straw it is sometimes difficult to harvest them with a binder. When the oat crop is to be cut for hay, some other variety with larger, taller straw should be grown. A plat of Sixty-Day oats at the Moro substation is shown in figure 14.

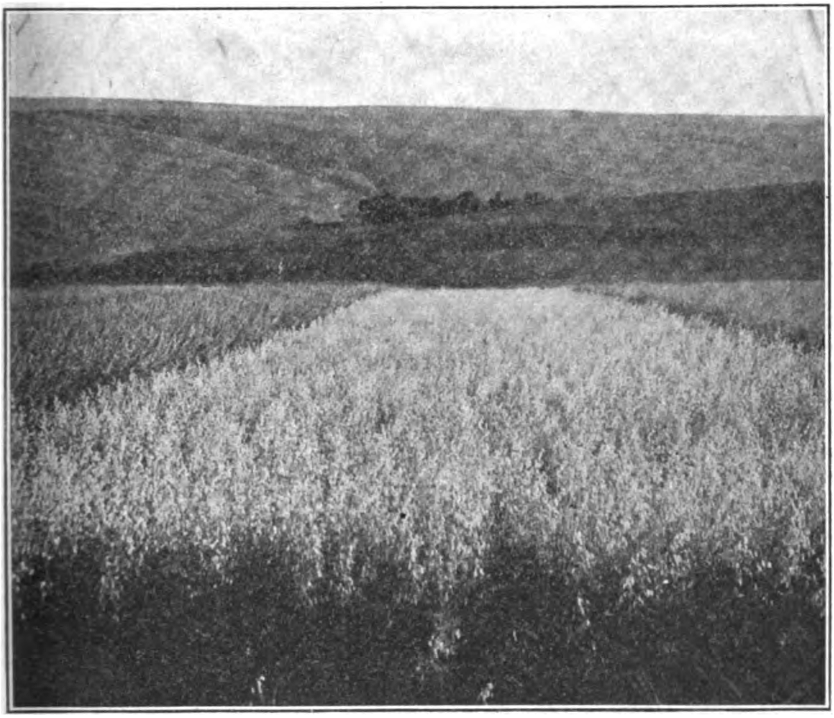

FIG. 14.—A twentieth-acre plat of Sixty-Day oats at the Moro substation in 1914.

*Siberian.*—The Siberian is an old European variety. The stock grown at the Moro substation was obtained a number of years ago from the Ontario Agricultural College, where this variety has been a leading one for many years. The Siberian variety ripens at Moro about 8 or 10 days later than the Kherson and Sixty-Day. It is a tall, rather slender strawed variety, with open heads. The kernels are white, long, and slender, but are considerably larger than those of the Kherson and Sixty-Day varieties. The average weight per bushel at Moro was 34 pounds, which is second only to that of the

Canadian. The 5-year average yield was only slightly less than that of the Sixty-Day and Kherson, exceeding that of any other variety by several bushels. A head of the Siberian oat is shown in figure 15.

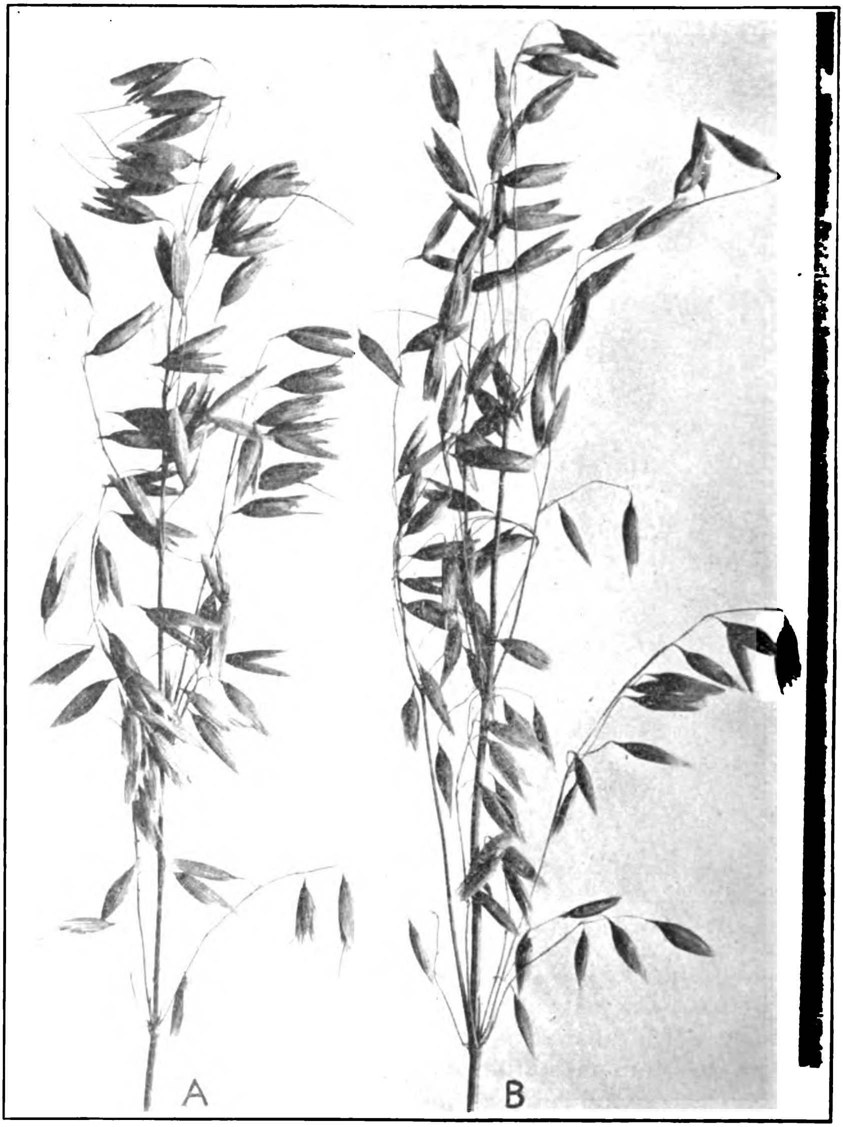

FIG. 15.—Heads of oats grown at the Moro substation: *A*, Siberian; *B*, Canadian.

*Canadian.*—The Canadian is a variety of oats which has been grown for many years in Scotland and in some portions of northern Europe as the Barley oat, so called because of its short, broad kernels, which somewhat resemble a grain of barley. The Canadian ripens at Moro about a week later than the Kherson and Sixty-Day, but two or three days earlier than most other varieties. The straw is tall and coarse, and the heads are very large and open (fig. 15). The kernels are white, short, and broad. The two prominent characteristics of this variety are the wide-spreading heads and the short kernels. One of its principal faults is a tendency to produce only one grain to the spikelet, the second or smaller grain often being entirely inclosed in the hull of the first. That this tendency has not been marked at the Moro substation is shown by the weight per bushel, which is higher than that of any other variety.

### SPRING BARLEY.

Next to wheat, barley is the most important cereal grown on the dry lands of the Columbia Basin. Most of the barley grown is sown in the spring, though at the lower elevations winter barley is grown successfully.

#### VARIETAL EXPERIMENTS.

At the substation 43 varieties of spring barley have been tried. Acre yields have been obtained from 13 of these in each of the five years, 1911 to 1915, inclusive. Owing to an exceedingly unfavorable season the barley yields were low in 1911. In 1912 the spring-barley varieties were placed on poor soil and no high yields were obtained. In 1913, 1914, and 1915 the yields of most of the varieties were considerably higher than in previous years, and spring barley exceeded any other spring crop in total weight of grain produced per acre.

In Table XVII will be found an alphabetical list of the spring-barley varieties grown two or more years, with the yields of each variety in bushels per acre. These yields are based on the yields of single tenth-acre plats in 1911, 1912, and 1913 and of duplicate twentieth-acre plats in 1914 and 1915, except as otherwise stated.

TABLE XVII.—*Yields of varieties of spring barley grown in rows and plats of various sizes at the Moro substation within the 5-year period, 1911 to 1915, inclusive, showing also the source of seed and group relationships.*

| Variety. | C. I. No. | Origin. | Group. | Yield per acre (bushels). | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1911 | 1912 | 1913 | 1914 | 1915 |
| **Abyssinian** | 668 | Abyssinia | 2-rowed | (a) | (a) | [b] 35.0 | [b] 22.1 | [b] 20.8 |
| **Do** | 669 | do | 6-rowed | (a) | (a) | [b] 32.5 | [b] 22.1 | [b] 18.2 |
| **Do** | 673 | do | do | (a) | (a) | [b] 32.5 | [c] 14.1 | ...... |
| **Do** | 674 | do | do | (a) | (a) | [b] 23.1 | [b] 3.9 | ...... |
| **Arlington** | 702 | Hybrid, Virginia. | do | ...... | (a) | [b] 32.5 | [b] 15.6 | [c] 26.5 |
| **Barbary** | 695 | Northern Africa. | do | (a) | (a) | (a) | [b] 32.5 | [c] 28.5 |
| **Beldi** | 190 | Algeria | do | 3.5 | 15.5 | 37.5 | 36.2 | 48.8 |
| **Black Abyssinian** | 670 | Abyssinia | do | (b) | (a) | [b] 10.3 | [b] 11.7 | [b] 16.0 |
| **Black Algerian** | 708-1 | Algeria | do | ...... | [b] 22.8 | [c] 39.3 | 46.3 | 46.4 |
| **Black Hull-less** | 596 | Southwestern Asia. | do | 3.7 | 17.8 | 37.9 | 25.2 | 36.6 |
| **Do** | | Hybrid, Oregon. | 6-rowed, hooded. | ...... | 20.7 | 33.1 | 23.3 | 27.0 |
| **Bohemian** | 27-1 | Austria | 2-rowed | (a) | (a) | [b] 25.0 | [c] 3.2 | [b] 4.0 |
| **Chevalier II** | 200 | Sweden | do | 6.4 | 26.2 | 31.0 | 21.8 | 32.5 |
| **Chili Brewing** | 657-1 | Chili | 6-rowed | (a) | [b] 28.0 | [c] 35.2 | 23.7 | 47.5 |

[a] Grown in head rows; yield not recorded.

[b] Grown in rod rows, usually unreplicated.

[c] Grown in 2-rod rows replicated 2 to 4 times.

TABLE XVII.—*Yields of varieties of spring barley grown in rows and plats of various sizes at the Moro substation within the 5-year period, 1911 to 1915, inclusive, showing also the source of seed and group relationships*—Continued.

| Variety. | C. I. No. | Origin. | Group. | Yield per acre (bushels). | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1911 | 1912 | 1913 | 1914 | 1915 |
| Coast | 691 | California (?) | 6-rowed | | | (b) | 37.9 | 42.5 |
| Do | 626 | ....do | ...do | 2.9 | 23.3 | 38.3 | 32.5 | 51.2 |
| Common Chili | 663 | Chili | ...do | (a) | b 31.2 | c 25.0 | | |
| Franconian | 679 | Germany | 2-rowed | (a) | (a) | b 45.5 | 29.2 | 47.5 |
| Gatami | 575 | China | 6-rowed | 5.9 | 16.8 | 36.4 | 41.2 | 36.0 |
| Gray Abyssinian | 672 | Abyssinia | ...do | (a) | b 35.1 | c 30.6 | b 22.8 | b [illegible] |
| Hanna | 24 | Austria | 2-rowed | 10.0 | 26.0 | 29.5 | 26.9 | 40.0 |
| Hannchen | 531 | Sweden | ...do | 8.4 | 25.2 | 48.3 | 32.8 | 46.4 |
| Heil's Hanna No. 1 | 681 | Germany | ...do | (a) | (a) | b 32.5 | b 28.3 | c 21.9 |
| Heil's Hanna No. 2 | 678 | ....do | ...do | (a) | (a) | b 20.8 | b 24.7 | c 5.9 |
| Heil's Hanna No. 3 | 682 | ....do | ...do | (a) | (a) | b 48.1 | | |
| Horsford (Texas Beardless). | 610 | Texas (?) | ...do | 5.4 | 24.5 | 14.4 | 20.8 | 22.5 |
| Himalaya (Guy Mayle) | 260-1 | China | 6-rowed | 2.9 | 6.0 | 33.8 | 25.0 | 42.2 |
| Imperial | 289 | France | 2-rowed | 4.3 | 25.0 | 17.3 | | |
| Mahan | 1144 | North Dakota | ...do | 12.0 | 22.0 | 25.1 | 28.0 | 36.0 |
| Manchuria (Minn. No. 105) | 576 | China | 6-rowed | | 23.9 | 33.0 | 34.6 | 27.0 |
| Manchuria (Minn. No. 6) | 638 | ....do | ...do | | | 34.3 | 25.4 | |
| Manchuria (O. A. C. No. 21). | | ....do | ...do | | | 34.0 | 23.4 | |
| Mandschurei (O. A. C.) | | ....do | ...do | | | 38.7 | 29.2 | 27.3 |
| Mansury | 617 | North Dakota (?). | 2-rowed | 2.7 | 21.2 | 31.2 | 24.2 | |
| Mariout | 261 | Egypt | 6-rowed | 6.3 | 28.0 | 40.6 | 42.1 | 54.5 |
| Oderbrucker | 537 | Germany | ...do | 7.0 | 23.5 | 30.6 | 34.5 | 41.5 |
| Peru | 707 | Peru | ...do | (a) | (a) | b 46.8 | 40.4 | 48.3 |
| Princess | 529 | Sweden | 2-rowed | 4.6 | 21.5 | 24.0 | 17.5 | |
| Do | 603 | ....do | ...do | 2.0 | 19.1 | 17.0 | 20.8 | |
| Salamanca | 689 | Spain | 6-rowed | 13.8 | (a) | b 11.7 | (a) | |
| Svanhals | 187 | Sweden | 2-rowed | 16.5 | 5.1 | 34.1 | 30.6 | 38.7 |
| White Smyrna (Ouchac) | 658 | Asia Minor | ...do | 9.3 | (a) | 42.0 | 36.7 | 49.8 |
| Wisconsin No. 9 | | Wisconsin | 6-rowed | | 22.3 | 25.4 | | |

[a] Grown in head rows; yield not recorded.
[b] Grown in rod rows, usually unreplicated.
[c] Grown in 2-rod rows replicated 2 to 4 times.

Table XVIII gives acre yields of the varieties that have been tested during the entire five years. The highest average yield per acre, 34.3 bushels, was obtained from the Mariout variety (C. I. No. 261), a 6-rowed form. The varieties giving the second and third highest average yields were White Smyrna (C. I. No. 658) and Hannchen (C. I. No. 531), both of which are 2-rowed barleys.

TABLE XVIII.—*Annual and average yields of 13 spring-barley varieties grown at the Moro substation in twentieth-acre or larger plats during the 5-year period, 1911 to 1915, inclusive.*

| Variety. | C. I. No. | Yield per acre (bushels). | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1911 | 1912 | 1913 | 1914 | 1915 | Average. |
| Black Hull-less | 596 | 3.7 | 17.8 | 37.9 | 25.2 | 36.6 | 24.2 |
| Beldi | 190 | 3.5 | 15.5 | 37.5 | 36.2 | 48.8 | 28.3 |
| Chevalier | 200 | 6.4 | 26.2 | 31.0 | 21.8 | 32.5 | 23.6 |
| Coast | 626 | 2.9 | 23.3 | 38.3 | 32.5 | 51.2 | 29.6 |
| Gatami | 575 | 5.9 | 16.8 | 36.4 | 41.2 | 36.0 | 27.3 |
| Hannchen | 531 | 8.4 | 25.2 | 48.3 | 32.8 | 46.4 | 32.2 |
| Hanna | 24 | 10.0 | 26.0 | 29.5 | 26.9 | 40.0 | 26.5 |
| Mariout | 261 | 6.3 | 28.0 | 40.6 | 42.1 | 54.5 | 34.3 |
| Mahan | 1144 | 12.0 | 22.0 | 25.1 | 28.0 | 36.0 | 24.6 |
| Manchuria (Minn. No. 105) | 576 | a 6.4 | 23.9 | 33.0 | 34.6 | 27.0 | 25.0 |
| Oderbrucker | 537 | 7.0 | 23.5 | 30.6 | 34.5 | 41.5 | 27.4 |
| Svanhals | 187 | 13.8 | 25.1 | 34.1 | 30.6 | 38.7 | 28.5 |
| White Smyrna | 658 | 9.3 | 27.0 | 42.0 | 36.7 | 49.8 | 33.0 |

[a] Estimated yield by comparison with yield of other varieties during 1912, 1913, 1914, and 1915.

In Table XIX the spring-barley varieties are arranged in groups of related varieties, showing the 5-year average yield of each variety and the average yield of each group. Typical heads of the leading varieties of barley at the Moro substation are shown in figure 16.

TABLE XIX.—*Average yields of spring-barley varieties grown at the Moro substation for the 5-year period, 1911 to 1915, inclusive, arranged in groups of related varieties.*

| Groups. | C. I. No. | Yield per acre. |
|---|---|---|
| 1. Six-rowed (hulled): | | *Bushels.* |
| Beldi | 190 | 28.3 |
| Coast (Common California) | 626 | 29.6 |
| Gatami | 575 | 27.8 |
| Manchuria (Minn. No. 105) | 576 | 29.6 |
| Mariout | 261 | 34.3 |
| Oderbrucker | 537 | 29.4 |
| Average | | 29.8 |
| 2. Six-rowed naked (hull-less): | | |
| Black Hull-less | 596 | 24.2 |
| Black Hull-less (Union, Oreg.) | | [a] 26.0 |
| Average | | 22.8 |
| 3. Two-rowed (hulled): | | |
| Chevalier | 200 | 23.6 |
| Hannchen | 531 | 32.2 |
| Hanna | 24 | 26.5 |
| Mahan | 1144 | 24.6 |
| Svanhals | 187 | 28.5 |
| White Smyrna | 658 | 33.0 |
| Average | | 28.0 |

[a] Average yield for four years only, 1912-1915. The average yield of Black Hull-less (C. I. No. 596) in the same four years was 29.4 bushels.

### DESCRIPTIONS OF THE BEST VARIETIES.

*The 6-rowed varieties.*—The leading 6-rowed varieties, as shown in Table XIX, are Mariout, Coast, Oderbrucker, and Beldi. Heads of the first three varieties are shown in figure 16.

The Mariout (C. I. No. 261) is an Egyptian variety which is characterized by a compact spike of the type often called club, although it possesses this characteristic to a lesser degree than the White Club. The kernel is somewhat coarse and the beard is not always entirely broken off in thrashing. It is an early, heavy-yielding variety in this section.

The Coast variety (C. I. No. 626) is the common 6-rowed barley grown upon the Pacific slope and in the Columbia Basin. It is called by various names, such as Common California, Bay Brewing, and sometimes Blue barley. The spike is less compact than that of the Mariout, and in many localities the plant is somewhat taller. Like the Mariout, the awn is not entirely removed in thrashing. It is a large-kerneled, heavy-yielding variety. It has been grown for many years in the western United States and probably came originally from Egypt.

Beldi (C. I. No. 190) is another North African variety, which closely resembles the Coast. It is, however, slightly earlier, and the spike and straw are somewhat shorter.

*The 2-rowed varieties.*—Of the 2-rowed varieties the Hannchen, White Smyrna, and Svanhals have given the best results. Heads of the Hannchen and White Smyrna barleys are shown in figure 16.

The Hannchen (C. I. No. 531) is a 2-rowed variety, with a narrow, nodding spike. It was produced by the Swedish Plant-Breeding Association of Svalof, Sweden, and was a selection from Hanna. Throughout most of the northern United States it is somewhat earlier than Hanna and a better yielder.

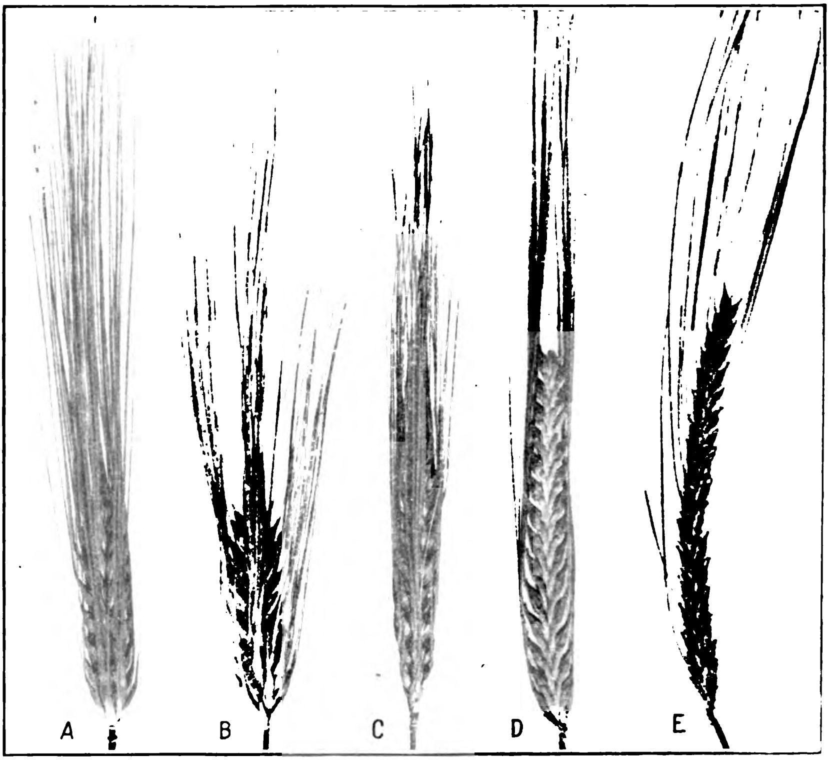

FIG. 16.—Heads of five varieties of spring barley grown at the Moro substation: *A*, Coast; *B*, Mariout; *C*, Oderbrucker; *D*, White Smyrna; *E*, Hannchen.

White Smyrna (C. I. No. 658) came originally from Asia Minor. It is a very large kerneled, 2-rowed variety, with a nodding spike. It has a very short straw, and for this reason often gives an unfavorable impression when first seen. It can be harvested successfully, however, and is a very heavy yielding variety. It is early, stands drought well, and is well adapted to the Columbia Basin uplands.

The variety Svanhals (C. I. No. 187) was produced by the Swedish Plant-Breeding Association. It has a wide, erect, 2-rowed spike, with large kernels and a stiff straw. It very seldom lodges, and it gives satisfactory yields throughout most of the western United States, but is hardly equal to the Hannchen and White Smyrna in this respect. This variety has been rather widely distributed under the name Swanneck, which is a translation of the Swedish name.

### COMPARATIVE VALUE OF WHEAT, OATS, AND BARLEY.

Table XX gives comparative figures on the acre yields of three spring crops, wheat, barley, and oats, and the pound values and acre values of these crops. The price per pound is based on the average price of these cereals in Oregon on December 1 in the 10 years, 1905 to 1914, inclusive, as given by the Bureau of Crop Estimates.[1] The average yields in this table are those obtained in plat tests at the Moro substation during 1913, 1914, and 1915. The average yields and the acre values for the leading variety of each crop in the five years, 1911 to 1915, inclusive, are also given.

TABLE XX.—*Average acre yields of all spring wheat, oat, and barley varieties grown at the Moro substation in 1913, 1914, and 1915, and of the best variety of each for the 5-year period, 1911 to 1915, inclusive, with average values based on the average farm price of these cereals in the 10-year period, 1905 to 1914, inclusive.*

| Crop. | Price per pound. | Average for all varieties, 1913 to 1915. | | Best variety, 1911 to 1915. | | |
|---|---|---|---|---|---|---|
| | | Yield per acre. | Value per acre. | Name. | Yield per acre. | Value per acre. |
| | *Cents.* | *Pounds.* | | | *Pounds.* | |
| Spring barley | 1.23 | 1,572 | $19.33 | Mariout | 1,646 | $20.35 |
| Spring oats | 1.38 | 1,485 | 20.49 | Kherson | 1,402 | 19.35 |
| Spring wheat | 1.35 | 1,296 | 17.50 | Early Baart | 1,362 | 18.39 |

Table XX shows that oats lead in value per acre of the three cereals for the three years, 1913 to 1915, barley being second and wheat third.

There is little difference in acre value between the crops when only the highest yielding variety of each crop is considered. Both oats and barley, however, have given higher yields in pounds per acre than spring wheat, and the value per acre based on the 10-year average farm price of these highest yielding varieties is highest for the barley, with oats $1 and wheat $1.96 per acre less.

### SPRING EMMER.

Spring emmer has had a thorough trial at the substation. It is apparently less drought resistant than wheat, oats, and barley. The acre yields have been considerably less than those of most varieties of other spring grains. Spring emmer (frequently advertised as spelt by seed companies) is apparently not so well adapted to Columbia Basin conditions as either oats or barley.

---

[1] Statistics of principal crops. U. S. Dept. Agr. Yearbook, 1915, p. 423, 435, 441. 1916.

One variety (C. I. No. 1524) has been tested since 1911, and the highest acre yield has been 31.5 bushels of 32 pounds each. The average yield in the five years was 21.8 bushels per acre, or less than half the number of pounds per acre yielded by Kherson oats or Mariout barley in the same period.

### GRAIN SORGHUMS.

Several varieties of the grain sorghums, including Manchu and White kaoliang, milo, feterita (Sudan durra), and kafir, have been tried, but with the exception of Manchu kaoliang all have been discarded. The cold spring weather in this section makes it difficult to secure good stands of most varieties of sorghums.

The Manchu kaoliang has given the best results, but the yields have not been large enough to recommend this crop for trial by farmers.

Two varieties of broom corn have also been grown. Fair seed yields have been obtained, but the brush produced has been of poor quality.

### SUMMARY.

Cooperative experiments with cereals have been conducted at the Moro substation during the five years, 1911 to 1915, inclusive.

Moro is located in Sherman County, in the north-central part of Oregon, on the rolling hills of the Columbia Basin, about 15 miles from the Columbia River.

The elevation of the substation is approximately 2,000 feet. The soil and climate are typical of a large part of the Columbia Basin in Oregon and Washington.

The average annual precipitation at or near Moro in the past 11 years has been 11.35 inches. The average seasonal precipitation (March to July, inclusive) in the five years, 1911 to 1915, inclusive, was 3.83 inches.

The average evaporation from a free water surface was 45.07 inches during the seven months, April to October, inclusive, in the five years, 1911 to 1915, inclusive.

The ratios of evaporation to seasonal precipitation and to annual precipitation are higher at the Moro substation than at the substations at Nephi, Utah, or Moccasin, Mont.

The average frost-free period in the five years, 1911 to 1915, inclusive, was 155.8 days. The average date of the last frost (32° F.) in the spring was May 2, and of the first frost in the fall, October 5.

The average wind velocity for the years 1911 to 1915, inclusive, was 5.9 miles per hour.

The experimental work with grains at the Moro substation includes varietal testing and breeding, crop rotation, and tillage experiments. Only the results of varietal experiments with spring grains are reported in this bulletin.

Seventy-six varieties of spring wheat have been tested for two or more years. Early Baart wheat (C. I. No. 1697) produced the highest average yield, 22.2 bushels per acre, in the five years, 1911 to 1915, inclusive. The selection from Koola (C. I. No. 2203–2) gave the highest three-year average yield, 27.7 bushels per acre, in the years 1913, 1914, and 1915.

The average yield of 14 varieties of common and club wheat varieties in 1913, 1914, and 1915 exceeded the average yield of two durum varieties by 3.5 bushels per acre. The average yield of the highest yielding common wheat exceeded the average yield of the highest yielding durum wheat by 7.7 bushels per acre in the same period.

Milling and baking tests of several of the spring-wheat varieties grown at the Moro substation have been made by the Plant Chemical Laboratory of the Bureau of Chemistry of the United States Department of Agriculture. These tests indicate that most of the varieties are as good as and some are better milling wheats than the Pacific Bluestem, which is the standard spring wheat of the Columbia Basin.

Date-of-seeding experiments with Pacific Bluestem spring wheat indicate that seeding as early in the spring as possible gives the best results.

Rate-of-seeding experiments with the Pacific Bluestem variety indicate that for early spring seeding about 5 pecks per acre is the best rate. For late seeding 3 pecks per acre produced the highest yields.

Of the oat varieties under experiment, the early varieties, like Kherson and Sixty-Day, have given the best results, though Siberian, a variety maturing in midseason, has given yields practically as high as the Sixty-Day and Kherson in a 5-year average.

Forty-two varieties of spring barley have been tested, and 5-year average yields obtained for 13 varieties. The variety giving the highest average yield in the five years was Mariout, C. I. No. 261, a 6-rowed form, yielding 34.3 bushels per acre. The 2-rowed forms White Smyrna and Hannchen produced average yields in the same period of 33 and 32.2 bushels per acre, respectively.

Spring emmer has not given as good results as spring barley or oats.

The grain sorghums have not produced profitable returns. Of the varieties tested, Manchu kaoliang is the most promising.

The 5-year average acre yield in pounds of the highest yielding varieties of the three leading cereals was as follows: Wheat, 1,362 pounds; oats, 1,402 pounds; barley, 1,646 pounds.

Based on the 10-year average farm price of these cereals in Oregon, the acre value of wheat would be $18.39; oats, $19.35; and barley, $20.35.

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UNITED STATES DEPARTMENT OF AGRICULTURE

## BULLETIN No. 499

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER February 12, 1917

# THE MULCHED-BASIN SYSTEM OF IRRIGATED CITRUS CULTURE AND ITS BEARING ON THE CONTROL OF MOTTLE-LEAF

By
LYMAN J. BRIGGS, Biophysicist in Charge, C. A. JENSEN, Assistant in Plant Malnutrition Investigations, and J. W. McLANE, Laboratory Assistant, Office of Biophysical Investigations

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## INTRODUCTION.

Orange and lemon trees in California are subject to a functional disturbance known as mottle-leaf, which in its advanced stages results in a marked reduction in the yield and quality of the fruit. The characteristics of mottle-leaf have been discussed in a recent paper[1] dealing with a field and laboratory study of the relation of mottle-leaf to soil conditions. In that paper it was shown by statistical methods that the percentage of mottling in 120 orange groves studied was inversely correlated to the extent of 0.67 with the humus content of the soil, as represented by the organic matter extracted with 4 per cent ammonium hydroxid and determined colorimetrically by comparison with a freshly prepared gravimetric standard. In other words, one-half of the mottling is associated with and is apparently due to a deficiency in the humus content. The investigations of Schreiner and his colleagues, Shorey, Lathrop, and Walters, have demonstrated that the organic matter extracted from soil by an alkaline solution is a varying mixture of numerous organic compounds having widely different properties.[2] If the humus components which are active and perhaps essential in maintaining the nutrition of the orange trees could have been separated from the mixture, a still higher inverse correlation would probably have been obtained between the amount of these essential or active constituents and the percentage of mottling. The analytical difficulties involved. however, combined with the incompleteness of our knowledge regarding the active constituents of the humus, made such a procedure impracticable.

---

[1] The writers take this opportunity to express their obligation to the University of California Citrus Experiment Station and Graduate School of Tropical Agriculture at Riverside for the courtesies and facilities extended during the course of this work, and to the growers who have placed groves at the disposal of the Government for experimental purposes and who have provided the labor and materials necessary for the prosecution of the field experiments.

Mottle-leaf, however, is apparently not associated wholly with the low humus content of the soil. Groves which have been fertilized chiefly with manure and green cover crops are by no means always free from mottle-leaf. The evidence collected in the above-mentioned field survey indicated that the furrow system of irrigation and the intensive surface cultivation in vogue in these districts may be in part responsible for the deterioration of the groves. The present bulletin deals with an investigation of this phase of the problem. Special attention is given to a new method of citrus culture, which the writers have termed the mulched-basin system, in which the trees are irrigated by means of basins heavily mulched with organic material, the soluble organic compounds resulting from the decomposition of the mulch being carried by the irrigation water into the soil. The soil-moisture conditions and the yields under the mulched-basin system and the furrow-irrigation system are compared, and the results of determinations of the rate of increase of the humus content of the soil under the mulched-basin system are presented.

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[1] Briggs, L. J., Jensen, C. A., and McLane, J. W. Mottle-leaf of citrus trees in relation to soil conditions. *In* Jour. Agr. Research, v. 6, no. 19, p. 721–739; pl. H and 96–97. 1916.

[2] Schreiner, O., and Shorey, E. C. Chemical nature of soil organic matter. U. S. Dept. Agr., Bur. Soils Bul. 74, 48 p., 1 pl. 1910.

Lathrop, E. C. Protein decomposition in soils. *In* Soil Science, v. 1, no. 6, p. 509–532. 1916.

## CULTURAL PRACTICE IN THE CITRUS DISTRICTS OF CALIFORNIA.

Irrigation is necessary in all the citrus districts of California, the rainfall being confined almost wholly to the winter months. The location of many of the groves on high land near the foothills, in order to lessen the danger of frost injury, has necessitated pumping water to high levels, with a proportionate increase in the cost. The limited water supply and its high cost have in turn led to the nearly universal practice of maintaining a deep soil mulch throughout the grove during the summer months, in order to conserve the moisture supply as much as possible.

The groves are usually irrigated through furrows about every 30 days during the summer. Three to five furrows are made between the tree rows, extending through the mulch to the uncultivated soil. As soon as the soil is dry enough after irrigation to permit working, the furrows are closed and the mulch again established. In the Riverside district the furrows are not, as a rule, led under the trees or between the trees in the tree row, so that the soil in the tree row (nearly half the total area) receives no irrigation water directly. The lateral movement of water in many of the soils studied is so slight that the soil in the tree row receives very little water during the summer and often becomes very dry and hard.

The feeding root system of citrus trees is usually shallow, and deep plowing results in a severe root pruning. It is perhaps on this account that deep plowing is not more often practiced. Cover crops are sometimes grown during the winter, and these are plowed under if heavy; but the disk harrow is more commonly used to work manure and fertilizer into the soil.

### ACCUMULATION OF PLANT FOOD IN THE SURFACE SOIL UNDER FURROW IRRIGATION.

The bottom of the irrigation furrow is usually below the cultivated soil. The water is consequently applied for the most part below the soil containing the fertilizer. During irrigation the water moves upward by capillary action from the bottom of the furrow into the surface soil containing the fertilizer, but there is little or no downward movement of the water through the fertilized layer of soil into the root zone. After irrigation the upward capillary movement of the soil solution continues for a time, the soluble salts being carried to the surface, where they are deposited as the moisture evaporates. The result is that the plant-food elements reach the root zone very slowly, the tendency being for the soluble constituents to accumulate in the cultivated surface soil, where there is practically no root development. It is only during the rainy season that there is any appreciable downward movement of the water through this surface soil into the root zone.

The accumulation of the soluble soil constituents near the surface is strikingly in evidence during the summer months in almost any heavily fertilized grove under furrow irrigation. The sides of the furrows and the surface of the ridges between the furrows will be found coated with a brown crust which closely resembles an ordinary "alkali" crust as seen in saline districts. This crust has been found by Breazeale to be so rich in soluble salts that it will kill young seedling oranges or lemons, the seedlings sometimes dying overnight. The soils of the area do not normally contain enough soluble matter to bear any resemblance to "alkali" soils; but these surface crusts illustrate very strikingly the tendency under this system of fertilization and irrigation of the soluble constituents to move into and accumulate in the surface soil.

## PLOWSOLE.

Furrow irrigation and intensive surface cultivation often promote the formation of a "plowsole," or incipient hardpan, under the soil mulch, varying in thickness from 3 inches to 2 feet. This layer of soil beneath the mulch frequently becomes so hard as to polish under the point of the plow when the irrigation furrows are opened. A long time is required for irrigation water to penetrate it, and it offers a serious obstacle to the development of the roots of citrus trees. Deep plowing loosens the plowsole temporarily, but destroys the roots to the depth of plowing, and the plowsole soon forms again.

## ORGANIC MULCHING.

The study of the cause of mottle-leaf led to experiments having as their object the development of a method of fertilizing and irrigating citrus trees which would avoid the objections of the present system. The use of surface mulches of organic material, such as straw, manure, damaged alfalfa, etc., as a substitute for the intensive cultivation was suggested in 1912 by one of the writers as a possible solution of the problem.[1] A trial of the organic surface mulch was inaugurated in 1913 on a small field plat of lemons on the Limoneria Ranch near Santa Paula, Cal. Under date of February 24, 1915, Mr. James Culbertson, assistant manager of the Limoneira Co., reported upon this experiment as follows:

> You will doubtless remember our discussion . . . a year ago last December when the possible value of mulching as a corrective for chlorosis was the topic. Upon reaching home I had three short rows thoroughly mulched, one with sawdust, one with bean straw, and the third with fairly well rotted manure. They were not in the worst affected areas. Later in the spring, in May, when

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[1] At a meeting of the California Lemon Club, at which this idea was advanced, Prof. H. S. Fawcett, of the University of California Citrus Experiment Station, reported an orange grove on an island near the eastern coast of Florida that for many years had been successfully operated under the mulching system without cultivation; and he has since observed the organic mulch in use in Cuba.

Prof. Fawcett had returned from a trip to Florida and Cuba and brought back reports of having seen very marked recovery of trees, apparently similarly affected, brought about by heavy mulch, we selected six rows 49 trees long through the very center of our worst affected area. We first plowed the ground and, after running three large furrows for irrigation, covered three of these rows, spaces and all, with manure and three of them with bean straw to a depth of 4 to 6 inches. From the road in the valley below looking up toward the hill slope where this orchard lies one can see these six rows standing out in contrast like a belt of green ribbon across a yellow background. It is remarkable, and all in nine months. Later observations from the near-by hills reveal the fact that the small tract mulched over two years ago is also darker green than the surrounding orchard, though the contrast is not so great, because it lay among healthy trees and was itself a group of normal trees.[1]

While surface mulching of orchard trees in humid regions with organic material has long been practiced on a small scale, it has not, in the United States at least, been followed to any great extent. The results of recently reported investigations in Pennsylvania by Stewart[2] indicate, however, that surface mulches of strawy manure, alfalfa hay, or other organic material may be used with advantage and profit in the culture of apples on a commercial scale. Stewart summarizes his investigations in part as follows:

In general the mulch treatment, reinforced by outside materials, has been most efficient in improving the yield, growth, and average size of fruit in orchards up to about 20 years of age. In older orchards it has been surpassed slightly by tillage and cover crops, unless accompanied by adequate fertilization. It has also been most efficient in conserving moisture in all cases that have been determined.

The crop value of the present mulch has averaged 76½ bushels per acre annually in the seven normal comparisons available. Its annual gain over tillage and cover crops has averaged 15.8 bushels per acre in the same experiments. The mulch is therefore a valuable treatment when properly managed and when mulching materials are available at not over $7 per ton, unless tillage is not practicable. All mulches should be kept at least a foot away from the tree trunks, and a greater distance is desirable as the trees enlarge.

Fawcett,[3] of the California Citrus Experiment Station, has recently made the following observations regarding the use of organic mulches in citrus groves in Cuba, where the distribution of the rainfall is similar to that in Florida, the greater part occurring during the summer months:

At Herradura, Prof. F. S. Earle showed the writer a grapefruit grove on clay-loam soil underlain with stiff clay, where part of the grove had been mulched all over the ground. The soil in this orchard was uniform, and the trees were all of the same age—seven years. Part of the rows had been heavily mulched all over the ground with vegetable matter, grass, and weeds for three years, part of it for two years, part for 1½ years, and another part for nine months only. A few rows in the middle of the orchard had not been mulched at all, but had been plowed and cultivated to conserve moisture during the dry season, during the whole period of seven years. The difference between the mulched and unmulched trees was very marked and almost beyond belief. The trees mulched for three years past without cultivation had foliage of good color, were vigorous, comparatively free from scale insects, bearing a large amount of smooth-skinned, bright fruit, and the trees were two to four times as large in diameter of trunk and two to four times as large in spread of branches. The trees were also free from chlorosis. On the unmulched tract the trees were small, stunted, with small yellow, starved-looking leaves, with limbs dying back, and with only a very few fruits, these being russeted and inferior in quality. There was at least four to six times as much fruit on the mulched as on the unmulched trees. The trees mulched for two years instead of three also showed a proportional improvement. Even the trees mulched for only nine months showed marked improvement in color and the amount of the last new growth. The improvement in this orchard was in definite proportion to the length of time the soil had been covered with vegetable mulch.

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[1] As this bulletin is going to press Mr. Culbertson informs the writers that the six rows of mulched trees yielded 36 per cent more fruit in 1916 than the adjacent six rows of unmulched trees, although at the beginning of the experiment the rows selected for mulching were the lowest yielding rows in the block. At the present time (winter of 1916–17), however, the mulched rows are again becoming yellow, so that the future success of the surface mulch is still uncertain.

[2] Stewart, J. P. Cultural methods in bearing orchards. Penn. Agr. Exp. Sta. Bul. 141, 28 p., 4 fig. 1916.

[3] Fawcett, H. S. A comparison of some citrus conditions in Florida, Cuba, and California. *In* Mo. Bul. Cal. State Com. Hort., v. 5, No. 9, p. 321–337, fig. 108–117. 1916.

At Santiago de las Vegas on heavy, red, sticky soil, Mr. H. A. Van Herman had been mulching heavily all over the soil for the last five years and had stopped cultivating entirely during that time. Previous to that he had practiced deep and frequent cultivation, and the trees were said to have gone back rather than forward. Since beginning this heavy mulching, the trees have grown rapidly, are healthy and green in appearance, and have on them a large crop of fruit. Mr. Van Herman was one of the first to advocate heavy mulching all over the ground as a general practice in Cuba. He is convinced that it is the proper practice for most soils in a climatic condition like that of Cuba.

Some excellent groves were seen, however, on red clay soils, and also on deep clay-loam soils where a system of nearly clean cultivation was used, plowing in large amounts of organic matter and fertilizing liberally with commercial fertilizer. Many growers were placing a vegetable mulch directly under the trees, but cultivating and raising summer cover crops between the rows.

Dr. Felix Löhnis, of the Bureau of Plant Industry, informs the writers that a permanent organic mulch is often employed in the culture of fruit trees in Germany, especially along the roadsides. Leaves, straw, manure, and other organic material are used for this purpose. Coarse peat is also extensively used as a mulching material in districts where it is available.

## THE MULCHED BASIN.

In 1913 an opportunity was presented to lay out an experimental tract in a commercial orange grove at Sunny Mountain, near Riverside, Cal., to test further the effect of mulching without cultivation. At this time it was decided to combine mulching with a basin method of irrigation, and accordingly each tree in the section of the grove selected was basined by throwing up dikes 6 to 8 inches high midway between the tree rows in both directions, so that each dike formed a common division bank of two basins.[1] These square basins were mulched with manure in 1913, and in 1914 they received another mulching of manure (25 to 30 cubic feet per tree) and about 75 pounds of barley straw on top of the manure. In the summer of 1915, each basin received 1½ bales of damaged alfalfa hay.

The experiment included three rows of 16 trees each, making 48 trees in all, or approximately one-half acre. The irrigation water was applied by turning the water into the upper basin of each row separately and allowing it to overflow into the next basin below, and so down the entire row. This method of irrigation was found, however, to be unsuitable to the deep sandy loam soil of this tract. The upper basins were under water too long a time before the lower basins were irrigated, and the water at the upper end of the row penetrated the subsoil below the zone occupied by the principal feeding roots of the trees, resulting in waste. In order to exercise both control and economy of irrigation water, it is necessary to run a furrow down the entire length of the row just outside the basins, so that each basin can be irrigated separately. This procedure was subsequently adopted and is the one usually followed by growers who are installing mulched basins on a commercial scale.

## MOISTURE DETERMINATIONS IN THE SUNNY MOUNTAIN GROVE.

At intervals during 1914 duplicate soil samples were taken to a depth of 7 feet in two basins near the upper end of the middle row of basins, and similar samples were taken in two basins near the lower end of the same row, the two outside basined rows being considered as guard rows. Similarly, duplicate samples were taken in the furrow-irrigated part of the grove two tree rows distant from the basined tract, the trees selected for sampling being opposite the basined trees sampled.

In Table I are given the results of moisture determinations made in this experimental tract during the seasons of 1914 and 1915. In 1914 the total moisture averaged about 3.7 per cent higher in the basins than in the check. The moisture available for growth in the first 3 feet of soil in the basins also averaged 3.8 per cent higher than in the check, being an equivalent of approximately 4 miner's inches per acre flowing 24 hours. It will also be noticed (sec. C) that while the first 3 feet of soil under the basins never dried down to the wilting coefficient, the first 3 feet of soil in the check dried out below that percentage three times during the two years, and at four other periods during the two seasons the wilting coefficient was nearly reached. In other words, the trees in the check were wilted three times during the two summer seasons, while the trees in the basins never wilted. It will be seen from a comparison of sections C and D that this wilting took place with available moisture in the fourth foot of soil.

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[1] While the mulched basin was developed independently by the writers, we have since learned that Mr. J. R. Hodges installed several mulched basins in a grove at Covina, Cal., at an earlier date (1911). So far as the writers know, this was the first use of the system.

TABLE I.—*Average percentages of total and available soil moisture in the Sunny Mountain grove, California, in 1914 and 1915.*

[NOTE.—A miner's inch of water flowing 24 hours will increase the moisture content of an acre of soil approximately 1 per cent to a depth of 3 feet.]

| Soil treatment,[1] 1914. | July 7. | Aug. 1. | Before irrigation, Aug. 15. | Sept. 2. | Before irrigation, Sept. 21. | After irrigation. | | Before irrigation, Nov. 30. | Average for season. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Oct. 6. | Nov. 4. | | |
| *A*.—Total in the first 3 feet: | | | | | | | | | |
| Mulched | 9.4 | 12.2 | 8.9 | 12.9 | 8.2 | 15.2 | 18.8 | 11.1 | 12.1 |
| Cultivated | 5.7 | 7.7 | 5.9 | 8.9 | 5.5 | 11.3 | 14.6 | 6.5 | 8.3 |
| *B*.—Total in the second 3 feet: | | | | | | | | | |
| Mulched | 10.8 | 11.3 | 10.4 | 9.9 | 10.1 | 11.9 | 15.9 | 11.0 | 11.3 |
| Cultivated | 8.6 | 9.1 | 8.9 | 9.2 | 8.3 | 7.9 | 11.8 | 7.9 | 7.7 |
| *C*.—Available in the first 3 feet: | | | | | | | | | |
| Mulched | 2.6 | 3.2 | 2.5 | 6.2 | 1.7 | 8.5 | 12.1 | 4.7 | 5.2 |
| Cultivated | 2.0 | 1.0 | .6 | 2.6 | —.6 | 3.2 | 8.4 | .6 | 1.5 |
| *D*.—Available in the second 3 feet: | | | | | | | | | |
| Mulched | 4.2 | 4.2 | 4.2 | 3.4 | 3.6 | 5.2 | 9.3 | 4.8 | 4.9 |
| Cultivated | 1.1 | 2.4 | 2.6 | 2.5 | 2.0 | 2.5 | 5.3 | 1.8 | 2.5 |

| Soil treatment,[1] 1915. | Dates of sampling before and after irrigation. | | | | | | | | | | | Average for season. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before, Apr. 9. | After, Apr. 22. | Before, June 2. | After, June 15. | Before, July 10. | After, July 19. | Before, Aug. 6. | After, Aug. 23. | Before Sept. 25. | After, Oct. 2. | Before, Oct. 30. | |
| *A*.—Total in the first 3 feet: | | | | | | | | | | | | |
| Mulched | 8.8 | 17.8 | 9.5 | 11.8 | 8.7 | 14.4 | 9.4 | 14.7 | 9.1 | 13.9 | 9.8 | 11.6 |
| Cultivated | 7.2 | 15.1 | 8.6 | 11.2 | 5.9 | 10.4 | 5.6 | 9.9 | 5.0 | 10.9 | 4.3 | 8.6 |
| *B*.—Total in the second 3 feet: | | | | | | | | | | | | |
| Mulched | 10.6 | 12.8 | 10.4 | 12.2 | 10.0 | 11.5 | 11.0 | 11.5 | 10.1 | 11.7 | 10.4 | 11.1 |
| Cultivated | 6.8 | 11.5 | 10.0 | 10.3 | 9.6 | 9.8 | 9.0 | 9.0 | 7.4 | 8.7 | 7.3 | 9.1 |
| *C*.—Available in the first 3 feet: | | | | | | | | | | | | |
| Mulched | 2.7 | 10.9 | 2.8 | 7.8 | 2.7 | 7.8 | 2.9 | 8.6 | 3.1 | 7.2 | 3.6 | 5.4 |
| Cultivated | 1.8 | 9.1 | 2.5 | 5.2 | .7 | 3.8 | .5 | 4.4 | —.6 | 5.5 | —1.2 | 2.0 |
| *D*.—Available in the second 3 feet: | | | | | | | | | | | | |
| Mulched | 4.6 | 6.6 | 3.8 | 6.0 | 4.9 | 4.2 | 5.1 | 5.7 | 3.8 | 5.8 | 4.7 | 5.0 |
| Cultivated | 2.6 | 5.3 | 3.3 | 4.6 | 3.8 | 3.4 | 4.8 | 2.8 | 2.3 | 2.8 | 1.0 | 3.3 |

[1] The mulched treatments were with basin irrigation; the cultivated, with furrow irrigation.

## SOIL-MOISTURE MEASUREMENTS IN BASINS, UNDER COVER CROPS, AND UNDER A SOIL MULCH IN THE VIVIENDA GROVE.

In the spring of 1915 a more extended series of experiments was started in an orange grove on sandy loam soil in the Vivienda tract, near Riverside. This soil is a little heavier than that of the Sunny Mountain grove.

The treatments included (1) spreading manure broadcast in the irrigated space between the tree rows and disking it in; (2) burying the manure in a circular trench 18 inches wide and 12 inches deep, located under the drip of the tree; (3) applying the manure as a surface mulch in the basin, which was approximately 15 feet in diameter, with the tree in the center; (4) trenches containing alfalfa in place of manure; (5) basins mulched with alfalfa in place of manure; (6) sweet clover as an irrigated cover crop between the tree rows; (7) barley as an irrigated cover crop; and (8) the usual disk cultivation and furrow irrigation as a check. The treatments were also repeated with the addition per tree of about 100 pounds of flue dust from the neighboring cement works, having the following composition (analysis by J. F. Breazeale):

| | Per cent. |
|---|---|
| Calcium carbonate | 53.40 |
| Calcium oxid | 13.16 |
| Calcium sulphate | 8.89 |
| Phosphoric acid ($P_2O_5$) | .18 |
| Potash ($K_2O$) | .95 |
| Insoluble (in dilute HCl) | 13.73 |

Twenty cubic feet of manure per tree were used in each of the manure experiments, and one bale of alfalfa per tree (about 125 pounds) was used in each experiment with alfalfa. A row of orange trees (about 48 trees) was used for each treatment, and each alternate row was left untreated as a guard.

TABLE II.—*Average percentages of total soil moisture to a depth of 3 feet in the Vivienda grove, California, in 1915.*

| Soil treatment. | Dates of sampling before and after irrigation. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | After, June 7. | Before, June 23. | After, June 26. | Before, July 16. | After, July 23. | Before, Aug. 9. | After, Aug. 23. | Before, Sept. 4. | After, Sept. 18. | Before, Oct. 4. | After, Oct. 11. | Before, Oct. 30. |
| Manure: | | | | | | | | | | | | |
| Surface disked | 12.2 | 7.9 | 14.2 | 7.4 | 14.0 | 7.1 | 9.7 | 7.4 | (1) | ...... | ...... | ...... |
| Same, plus lime | 11.3 | 8.9 | 14.8 | 8.0 | 13.1 | 8.2 | 8.5 | 6.7 | (1) | ...... | ...... | ...... |
| Trenched | 12.8 | 7.5 | 11.7 | 7.4 | 6.5 | 3.3 | 4.8 | 6.6 | (1) | ...... | ...... | ...... |
| In basins | 12.9 | 9.0 | 12.9 | 9.2 | 11.6 | 8.5 | 12.2 | 8.1 | 12.3 | 7.8 | 12.8 | 6.3 |
| Same, plus lime | ...... | 10.0 | 14.4 | 9.0 | 12.8 | 9.2 | 14.8 | 9.4 | 13.7 | 7.8 | 14.1 | 8.6 |
| Alfalfa: | | | | | | | | | | | | |
| Trenched | 14.0 | 9.2 | 14.8 | 7.5 | 8.7 | 3.4 | 3.4 | 3.0 | (1) | ...... | ...... | ...... |
| In basins | 12.4 | 9.7 | 12.2 | 8.7 | 11.5 | 8.5 | 11.5 | 7.8 | 11.7 | 6.8 | 14.0 | 6.2 |
| Same, plus lime | ...... | 10.6 | 13.8 | 10.4 | 12.8 | 10.3 | 13.5 | 9.8 | 13.9 | 9.7 | 12.3 | 9.7 |
| Sweet clover: | | | | | | | | | | | | |
| Cover crop | 13.1 | 6.7 | 13.9 | 4.8 | 15.1 | 6.9 | (1) | ...... | ...... | ...... | ...... | ...... |
| Same, plus lime | 11.3 | 6.0 | 13.5 | 4.9 | 14.4 | 5.3 | (1) | ...... | ...... | ...... | ...... | ...... |
| Barley: | | | | | | | | | | | | |
| Cover crop | 12.2 | 6.7 | 14.2 | 5.7 | (1) | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Same, plus lime | 11.7 | 5.9 | 13.9 | 5.6 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Disk cultivated | 12.5 | 8.5 | 14.9 | 7.5 | 14.2 | 6.2 | 8.8 | 5.5 | (1) | ...... | ...... | ...... |
| Same, plus lime | 12.0 | 8.5 | 14.5 | 7.7 | 13.1 | 5.7 | 7.9 | 4.7 | (1) | ...... | ...... | ...... |

[1] Basined.

Table II gives the percentage of total moisture found in the soil under the various treatments. The trees in the trenching experiments were irrigated by running a furrow over the trenches, the assumption being that the water would follow the trench encircling the tree base. The basins were irrigated separately from a furrow along the sides, and the cover crops and disk-cultivated tree rows (including treatments 1, 2, and 8) were irrigated by furrows in the usual manner.

The trenches did not take up much water after the first two irrigations. The soil samples were taken directly in the trench, but 90° from the point of contact of the trench with the irrigation furrow, so that to reach the point of sampling the water would have had to move about 7 feet in the trench. These trenched trees were later basined, as they were not being properly irrigated, owing to the packing and decomposition of the organic matter in the trenches.

The barley did not make a strong growth and when nearly mature was from 18 to 20 inches high. It was disked into the soil in the latter part of July. The sweet clover was at first slow in growth, but by the middle of August it was 2 to 3 feet high. It was then disked in and the trees basined.

The results in Table II show that the use of the summer cover crops, especially sweet clover, resulted in a marked reduction of the water content of the soil compared with the other treatments. With the limited quantity of water available for irrigation in this district it is not practicable to maintain a suitable supply of organic matter in the soil by growing summer crops. The trees grown in conjunction with a cover crop in these trials also showed less new growth during the season than the trees under the other treatments, and the leaves were lighter in color. The cover crop, with its fine root system, secures so much of the water that the orange trees, which have a relatively coarse root system unprovided with root hairs, are bound to suffer.

The effect of the different treatments in conserving the growth water[1] is shown in Table III, which gives the percentage of available moisture to a depth of 3 feet before irrigation, this being the critical moisture period. The basin treatment was most effective in the conservation of moisture, the cultivated rows were next best, and cultivation with a surface application of manure disked in appeared to be slightly more effective than cultivation without manure. The lower moisture content of the soil where lime was added is attributable to the fact that the lime was used on the lower ends of the rows and also to the fact that the slope of the land was slightly greater at the lower end of the tract, so that the lime treatments received less water. Incidentally, this brings out another important advantage of the basin system, namely, that all trees may be given the same amount of water regardless of the physiography of the grove.

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[1] It is well known that a crop can not remove all the moisture from the soil in which it is growing. The percentage remaining at the time the crop wilts varies greatly with the soil type. The wilting coefficient of a soil is defined as the moisture content of the soil (expressed as a percentage of the dry weight) at the time when the leaves of the plant growing in that soil first undergo a permanent reduction in their moisture content as the result of a deficiency in the soil-moisture supply. By a permanent reduction is meant a condition from which the leaves can not recover in an approximately saturated atmosphere without the addition of water to the soil. The water in a soil in excess of its wilting coefficient is called the "growth water;" that is, it is the portion available for the growth of plants.

TABLE III.—*Average percentages of available soil moisture to a depth of 3 feet, before and after irrigation, in the Vivienda grove, California, in 1915.*

[NOTE.—Minus signs indicate that the moisture content was reduced below the wilting coefficient.]

| Soil treatment. | Before irrigation. | | | | | | | After irrigation. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | June 23. | July 16. | Aug. 9. | Sept. 4. | Oct. 4. | Oct. 30. | Average. | June 6. | June 26. | July 23. | Aug. 23. | Sept. 18. | Oct. 11. |
| **Manure:** | | | | | | | | | | | | | |
| Surface disked | 3.3 | 2.7 | 1.9 | 2.4 | (1) | ...... | 2.6 | 6.7 | 8.7 | 9.0 | 4.9 | (1) | ..... |
| Same, plus lime | 3.6 | 3.0 | 2.5 | 1.1 | (1) | ...... | 2.6 | 5.4 | 8.8 | 7.6 | 2.7 | (1) | ..... |
| Trenched | 2.5 | 2.2 | -2.1 | 1.1 | (1) | ...... | .9 | 7.4 | 6.1 | 1.4 | -.6 | (1) | ..... |
| In basins | 4.1 | 4.1 | 3.3 | 2.9 | 2.9 | 1.4 | 3.1 | 7.2 | 7.2 | 6.5 | 6.6 | 6.8 | 7.2 |
| Same, plus lime | 4.3 | 3.4 | 3.4 | 4.0 | 2.4 | 3.0 | 3.4 | ...... | 8.4 | 6.9 | 8.5 | 7.8 | 7.9 |
| **Alfalfa:** | | | | | | | | | | | | | |
| Trenched | 4.1 | 2.4 | -2.0 | -2.4 | (1) | ...... | .5 | 8.2 | 9.0 | 3.4 | -2.0 | (1) | ..... |
| In basins | 4.2 | 2.8 | 2.4 | 2.1 | 1.6 | .8 | 2.3 | 6.1 | 6.2 | 6.0 | 5.8 | 6.0 | 7.7 |
| Same, plus lime | 4.5 | 4.3 | 4.0 | 4.1 | 4.1 | 3.9 | 4.2 | ...... | 7.5 | 6.7 | 7.5 | 7.5 | 6.4 |
| **Sweet clover:** | | | | | | | | | | | | | |
| Cover crop | 1.8 | .4 | 1.1 | (1) | ...... | ...... | 1.1 | 6.9 | 8.1 | 9.7 | (1) | ...... | ..... |
| Same, plus lime | .4 | -2.4 | -.7 | (1) | ...... | ...... | -.9 | 4.8 | 7.2 | 8.2 | (1) | ...... | ..... |
| **Barley:** | | | | | | | | | | | | | |
| Cover crop | 1.5 | 2.7 | (1) | ...... | ...... | ...... | 2.1 | 6.4 | 8.5 | (1) | ...... | ...... | ..... |
| Same, plus lime | .5 | .2 | (1) | ...... | ...... | ...... | .4 | 5.4 | 7.5 | (1) | ...... | ...... | ..... |
| **Disk cultivated** | 3.4 | 2.4 | .7 | -.3 | (1) | ...... | 1.6 | 7.1 | 9.1 | 8.8 | 3.0 | (1) | ..... |
| **Same, plus lime** | 2.9 | 1.9 | -.3 | -.8 | (1) | ...... | .9 | 5.7 | 8.3 | 7.1 | 2.7 | (1) | ..... |

[1] Basined.

## BASIN AND COVER-CROP EXPERIMENTS IN THE VICTORIA GROVE.

Another series of experiments was also begun in the spring of 1915 on the Victoria tract, near Riverside, Cal., the soil being a red-clay loam with granite rock 3 to 4 feet below the surface. The upper layer of this granite to the depth of a few inches is sufficiently decomposed to be removed with a soil tube, but below this the rock is very hard.

The treatments in this grove, which were practically the same as those just discussed for the Vivienda grove, are given in the first column in Table IV,[1] which shows the average moisture content to a depth of 3 feet. The moisture available for growth before and after each irrigation is shown in Table V.

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[1] The check row given in Table IV was not cultivated, and conditions were such that another row for a cultivation test was not available.

TABLE IV.—*Average total percentages of soil moisture to a depth of 3 feet in the Victoria grove, California, in 1915.*

[NOTE.—The first four treatments were not irrigated between April 22 and June 10. The last six treatments were irrigated on May 20.]

| Soil treatment. | Dates of sampling before and after irrigation. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | After, Apr. 22. | Before, June 10. | After, June 22. | Before, July 12. | After, July 26. | Before, Aug. 12. | After, Aug. 25. | Before, Sept. 13. | After, Sept. 17. | Before, Oct. 12. |
| Alfalfa: | | | | | | | | | | |
| In basins | 17.2 | 12.8 | 14.5 | 10.6 | 15.0 | 11.9 | 15.7 | 10.5 | 14.5 | 11.1 |
| Same, plus lime | 17.9 | 12.5 | 15.7 | 11.1 | 18.4 | 11.7 | 17.7 | 12.0 | 17.5 | 12.5 |
| Manure: | | | | | | | | | | |
| In basins | 16.4 | 8.9 | 13.1 | 9.2 | 17.8 | 11.8 | 17.4 | 10.3 | 17.1 | 11.9 |
| Same, plus lime | 17.7 | 9.9 | 12.9 | 10.1 | 17.7 | 12.0 | 16.9 | 11.1 | 19.9 | 12.8 |
| Sweet clover: | | | | | | | | | | |
| Cover crop | ...... | 13.4 | 14.6 | 7.0 | 10.5 | 5.3 | (1) | ...... | ...... | ...... |
| Same, plus lime | ...... | 13.1 | 17.6 | 8.0 | 10.2 | 5.3 | (1) | ...... | ...... | ...... |
| Barley: | | | | | | | | | | |
| Cover crop | ...... | 11.3 | 10.4 | 7.4 | (1) | ...... | ...... | ...... | ...... | ...... |
| Same, plus lime | ...... | 11.0 | 10.2 | 5.9 | (1) | ...... | ...... | ...... | ...... | ...... |
| Uncultivated | ...... | 14.5 | 14.3 | 9.0 | 9.6 | 6.3 | 15.3 | 8.0 | (1) | ...... |
| Same, plus lime | ...... | 13.4 | 11.6 | 9.3 | 11.9 | 8.2 | 13.7 | 9.8 | (1) | ...... |

[1] Basined.

It is apparent from Table IV that the greatest reduction in moisture took place under the cover crops, the loss being greater than from the uncultivated row. This is brought out more clearly in Table V, which gives the amount of available moisture in the surface 3 feet of soil before irrigation, the critical moisture period. This table shows that the mulched-basin system is the only one that retained available moisture at all times. In all the other treatments the moisture content at some time during the summer was reduced below the wilting coefficient. This deficiency in the moisture supply in the case of the cover-crop tests was also shown by the appearance of the trees, which wilted badly during the summer before the irrigation periods came around.

TABLE V.—*Average percentages of available soil moisture to a depth of 3 feet, before and after monthly irrigations, in the Victoria grove, California, in 1915.*

| Soil treatments. | Before monthly irrigations. | | | | | | After monthly irrigations. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | June 10.[1] | July 12. | Aug. 13. | Sept. 13. | Oct. 12. | Average. | Apr. 22. | June 22. | July 26. | Aug. 25. | Sept. 17. |
| Alfalfa: | | | | | | | | | | | |
| In basins | 4.7 | 2.2 | 3.1 | 1.8 | 2.2 | 2.8 | 7.8 | 5.7 | 6.2 | 7.4 | 5.3 |
| Same, plus lime | 4.4 | 2.9 | 3.3 | 3.8 | 4.1 | 3.7 | 9.0 | 7.4 | 9.7 | 9.7 | 9.0 |
| Manure: | | | | | | | | | | | |
| In basins | .1 | .9 | 3.1 | 1.5 | 3.2 | 1.8 | 6.5 | 4.2 | 8.5 | 9.1 | 8.3 |
| Same, plus lime | .8 | 1.1 | 2.8 | 2.0 | 3.3 | 2.0 | 8.0 | 3.5 | 8.0 | 8.1 | 10.4 |
| Sweet clover: | | | | | | | | | | | |
| Cover crop | 5.0 | −1.0 | −2.4 | (2) | ...... | .5 | ...... | 6.2 | 1.9 | (2) | ...... |
| Same, plus lime | 4.5 | − .4 | −3.0 | (2) | ...... | .4 | ...... | 8.9 | 1.5 | (2) | ...... |
| Barley: | | | | | | | | | | | |
| Cover crop | 3.3 | − .8 | (2) | ...... | ...... | 1.3 | ...... | 2.2 | (2) | ...... | ...... |
| Same, plus lime | 3.4 | −2.6 | (2) | ...... | ...... | .4 | ...... | 1.4 | (2) | ...... | ...... |
| Uncultivated | 5.8 | .4 | −2.0 | − .7 | (2) | .9 | ...... | 5.7 | 1.1 | 6.7 | (2) |
| Same, plus lime | 4.3 | .6 | .7 | .9 | (2) | 1.6 | ...... | 2.4 | 3.0 | 5.1 | (2) |

[1] The last previous irrigation of basins was given on April 22; other treatments about May 20.
[2] Basined.

## FURROW IRRIGATION OFTEN NOT ADEQUATE.

The furrow system of irrigation often fails to provide the moisture necessary for good growing conditions for orange trees in the heavier types of soil. This was strikingly shown during the season of 1915, many orange groves wilting between irrigations. At one time during the summer a grove adjoining the Victoria grove showed wilting for several days before irrigation. Soil samples were taken at the time to determine the percentage of moisture present. The results are shown in Table VI, the moisture-determination figures representing the average moisture content to a depth of 3 feet of soil.

TABLE VI.—*Moisture conditions under wilted orange trees.*

| Condition of leaves. | Moisture equivalent. | Wilting coefficient. | Av rage moisture. | |
|---|---|---|---|---|
| | | | In soil. | Available. |
| | | | *Per cent.* | *Per cent.* |
| All leaves on tree badly wilted | 15.6 | 8.5 | 6.9 | −1.6 |
| Leaves on top third of tree badly wilted, lower two-thirds not wilted | 15.1 | 8.2 | 7.1 | − .1 |

The moisture determinations include the dry surface soil, which through surface evaporation dries out to about one-half the wilting coefficient, so that the average moisture content of the 3-foot section is about nine-tenths that of the soil actually occupied by the tree roots. The second tree mentioned in Table VI had been wilted for several days preceding the sampling. These observations on heavy soil and similar observations on light soil show that the wilting coefficient determined indirectly from the moisture equivalent of a soil agrees satisfactorily with direct determinations made in the groves.

## LATERAL MOVEMENT OF SOIL MOISTURE VERY SLIGHT.

The lateral movement of moisture in the heavy soils of the Victoria tract is very slight. After an irrigation considered sufficient to last about 28 days, the moisture was found to have penetrated laterally only about 18 inches from the irrigation furrow. In other words, there is practically no lateral movement of water toward the tree, the feeding roots being confined to the soil below the irrigation furrows.

The lateral movement of water was also found to be very slight in a basined grove at Redlands located on the same type of soil as the Victoria grove just discussed. Soil samples were taken on May 26, before the first spring irrigation, and the day after the grove was irrigated samples were again taken within a few inches of the first samples. Alfalfa was being grown in the furrows between the basins to supply mulching material. The basins in this grove were small and were separated in the tree row by spaces about 4 feet in width. These spaces between the basins were bare and unirrigated, the usual practice. The results of the moisture determinations presented in Table VII show no lateral movement of soil moisture from the basins into these spaces during irrigation.

TABLE VII.—*Available soil moisture before and after irrigation in an orange grove having alfalfa growing in the furrow rows at Redlands, Cal.*

| Depth. | Available moisture before irrigation (per cent). | | | Available moisture after irrigation (per cent). | | |
|---|---|---|---|---|---|---|
| | In basins. | In alfalfa furrow rows. | Between basins in tree rows, about 2 feet from basins. | In basins. | In alfalfa furrow rows. | Between basins in tree rows, about 2 feet from basins. |
| First foot | 4.2 | −1.4 | 0.9 | 7.4 | 4.9 | −0.[illegible] |
| Second foot | 4.8 | −.6 | 1.8 | 6.4 | .8 | 1.1 |
| Third foot | 5.1 | .1 | 2.1 | 5.5 | 1.0 | 2.4 |
| Fourth foot | 4.3 | .4 | 2.9 | 4.9 | 1.9 | 3.1 |
| Average | 4.6 | −.4 | 1.9 | 5.6 | 2.2 | 1.5 |

## SUMMER COVER CROPS IN ORANGE GROVES NOT PRACTICABLE WITHOUT AN INCREASED WATER SUPPLY.

The moisture conditions in the alfalfa furrow rows as shown in Table VII are quite typical of conditions found in other orange groves with alfalfa growing between the trees. In 1914, soil samples were taken in three groves of this kind after irrigation, and the moisture had penetrated only from 10 to 30 inches after a two or three days' run of water. The large amount of water removed by such crops and the bad effect on the orange trees of the competition with the cover crop have already been mentioned in connection with the experiments in the Victoria and Vivienda groves. With the amount of water usually available for irrigation in these districts (1 miner's inch to 5 acres), no summer cover crop of any kind can be grown in citrus groves in the areas studied without causing deterioration of the trees. Instances were found where summer crops, such as buckwheat and sweet clover, were grown quite regularly, but in these cases there was plenty of water available for both trees and cover crop.

## ORGANIC MULCHES MORE EFFECTIVE THAN SOIL MULCHES IN CONSERVING WATER.

Four cylindrical cans 24 inches high and 18 inches in diameter were filled with soil from the Victoria grove on June 25. The soil in the different cans was treated as follows: (1) Surface soil kept mulched, (2) surface soil left undisturbed, (3) seeded to barley, (4) covered with about 2 inches of alfalfa mulch. The soil contained 19.2 per cent of moisture when the cans were filled. The cans were weighed from time to time to determine the moisture loss, but only the final results need be given here. On August 3, 38 days after the initial weighing, the moisture content of the soil in the different cans was as follows: (1) Surface soil mulched, 14 per cent; (2) surface left undisturbed, 10.1 per cent; (3) seeded to barley, 3.1 per cent; (4) mulched with alfalfa, 18 per cent. The soil seeded to barley had reached the wilting coefficient by July 16, 21 days after the seed was planted.

These results show the relative effectiveness of a soil mulch and an alfalfa mulch in retaining moisture. The soil under the alfalfa mulch had lost but 1.2 per cent of moisture, while the soil under the dust mulch had lost 4 per cent, or over three times as much as the alfalfa-covered soil. The soil mulch in this test was, furthermore, kept in a much more effective condition than is practicable in a grove.

## EFFECT OF BASINING ON TREE GROWTH.

### THE SUNNY MOUNTAIN GROVE.

On the light soil of the Sunny Mountain experimental grove it was nearly a year before any very noticeable change occurred in the appearance of the mulched trees, but during the autumn of 1914 there was a distinct advance in the new growth on the trees in the basins as compared with the check trees.

The grove was badly infested with scale, for which it was fumigated in the fall of 1914, at a time when the new growth on the basined trees was well advanced. The basined trees, on account of the larger amount of new growth, were injured more by the fumigation than the check trees, but the trees soon recovered and again grew faster than the check trees. The beneficial effect of the mulched-basin treatment was also plainly in evidence on the untreated rows of trees immediately adjoining the experimental tract, showing that the root systems extend laterally to adjoining tree rows when conditions are favorable.

### THE VICTORIA GROVE.

The portion of the grove used for these experiments had been previously used as an experimental plat and had received sodium nitrate only as a fertilizer for four years. This experiment was terminated in 1913, and the plat was manured in 1914. The trees were in an unthrifty condition in 1914 and 67 per cent of the leaves were mottled. The trees were heavily pruned in the winter of 1914–15, so that the mottle-leaf was not so conspicuous as it had been previous to pruning, but the trees had made no visible response to the change in treatment.

A row of trees was basined in the latter part of April, and by the latter part of July, a little over three months, there was a remarkable improvement in the appearance of the basined row compared with the check trees. There was a vigorous new growth of leaves, which were large and velvety in texture, dark green in color, and almost free from mottling, while the new leaves on the trees in the check row were small and yellowish, more or less mottled, and never developed normally. The accompanying photograph (Pl. I) was taken about the middle of July and shows clearly the improvement in growth and color of the basined trees.

### THE VIVIENDA GROVE.

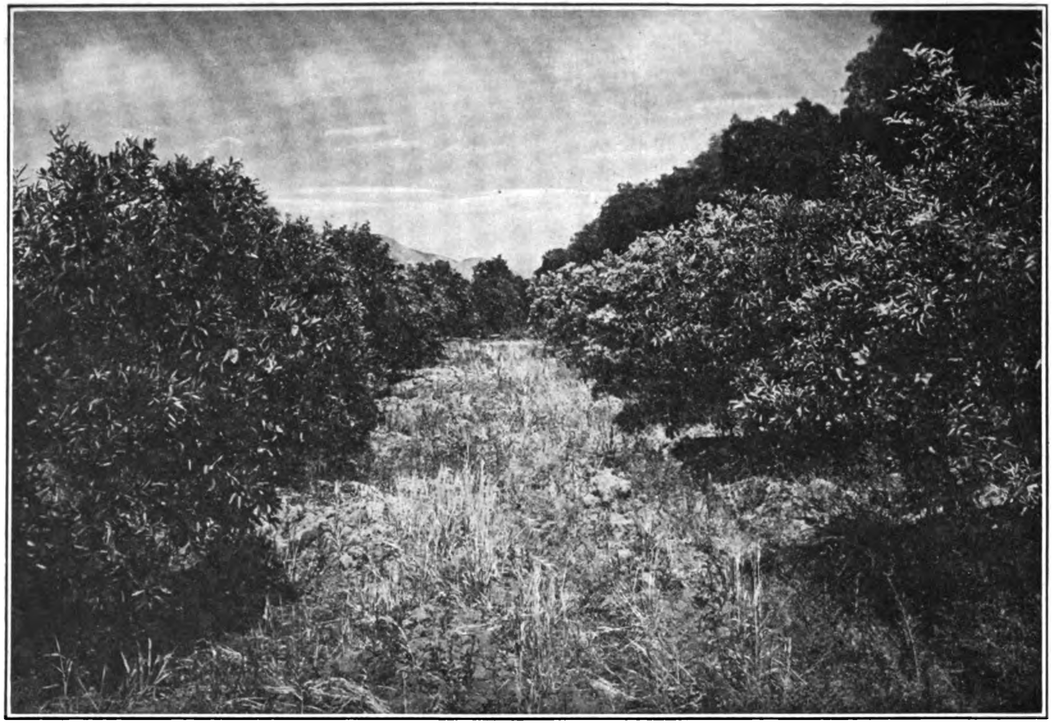
The basined trees in this grove did not respond to the mulched-basin treatment as rapidly as the basined trees in the Victoria grove, but by the fall of 1915 there was a very distinct improvement in the appearance of the basined trees when compared with the check trees.

## THE MULCHED BASIN IN RELATION TO SOIL TYPE.

The early response of trees on heavy soils to the mulched-basin treatment appears to be due to the more uniform moisture conditions under the mulch and also to the fact that more available moisture is present in the basins than under the furrow method. The heavy soils of the Victoria groves in general do not take water well, and there is very little lateral movement of water from the irrigation furrows. Soil samples taken 18 inches from a furrow immediately after irrigation frequently showed no increase in moisture due to irrigation. It appears, therefore, that under such a furrow system of irrigation, unless the number of furrows is greatly increased over the usual number, the heavy soils are not thoroughly irrigated, so that a considerable portion of the soil is devoid of available moisture during part of the irrigation season.

On the other hand, sandy loam soils, like those of the Vivienda and Sunny Mountain groves, take water more readily, so that after an irrigation the moisture content of these soils is more nearly uniform and the available moisture is higher than in heavier soils under furrow irrigation. The trees in the groves on the higher soils, therefore, do not suffer so much from lack of water under the furrow method of irrigation as the trees on the heavier soils.

Table VIII shows the available moisture after irrigation in the Vivienda (sandy loam) and Victoria (clay loam) groves. The sandy loam soils show more available moisture after irrigation than the



TWO ROWS OF ORANGE TREES IN THE VICTORIA GROVE IN CALIFORNIA, SHOWING THE EFFECT OF THE MULCHED-BASIN SYSTEM ON MOTTLE-LEAF AFTER THREE MONTHS' TREATMENT.

The left-hand row was under the mulched-basin system, while the right-hand row was furrow irrigated. The two rows at the beginning of the experiment were equally mottled. The light-yellow foliage of the furrow-irrigated row is clearly seen on the right, and the marked improvement of the basined row is shown in the dark foliage on the left. The ridges of the circular basins can be seen at the base of the trees of the left-hand row. The right-hand row is separated by a guard row from the pepper trees shown on the extreme right.

clay-loam soils where cover crops are grown or where the soil is cultivated. On the other hand, under the basin system the heavy soil has a little more available moisture after irrigation than the sandy loam soil.

TABLE VIII.—*Average available soil moisture to a depth of 3 feet in sandy loam (Vivienda grove) and in clay loam (Victoria grove) after irrigation.*

| Soil treatments. | Clay loam. | Sandy loam. | Soil treatments. | Clay loam. | Sandy loam. |
|---|---|---|---|---|---|
| Manure: | *Per cent.* | *Per cent.* | Sweet clover: | *Per cent.* | *Per cent.* |
| In basins | 7.3 | 6.9 | Cover crop | 4.2 | 8.2 |
| Same, plus lime | 7.6 | 7.9 | Same, plus lime | 5.2 | 6.7 |
| Alfalfa: | | | Barley: | | |
| In basins | 6.6 | 6.0 | Cover crop | 2.2 | 7.5 |
| Same, plus lime | 8.8 | 7.3 | Same, plus lime | 1.4 | 6.5 |
| | | | Cultivated | 4.0 | 6.5 |

Where groves are planted on heavy adobe soils, as is the case with some groves near Whittier, the use of the mulched basins has been found inadvisable. Heavy adobe soil swells when thoroughly moistened, and in this condition is practically impervious to water and to air. In the case of heavy adobe soils (derived from Pierre shale) on the Bellefourche Reclamation Project in South Dakota, it has been observed that the irrigation is effective only so long as the shrinkage cracks are in evidence. The water is distributed through the soil by means of these openings, and when the adobe has swelled sufficiently to close the cracks the soil will take no more water. The use of mulched basins on heavy adobe results in a more nearly uniform moisture condition at the surface and prevents the development of surface cracks. These fissures appear to be essential, or at least desirable, for the proper irrigation and aeration of heavy adobe. On the same ranch near Whittier, Cal., where the difficulty with heavy adobe was encountered, lemon trees on soil of a less pronounced adobe character have shown a most favorable response to the mulched-basin treatment.

## EFFECT OF THE MULCHED BASINS ON SOIL CONDITIONS AND ROOT GROWTH.

In all the experiments carried on with mulched basins having an area as large as the spread of the tree, irrigation once a month has been sufficient to maintain a good soil-moisture condition throughout the period between irrigations. The mulch also tends to maintain a moderate and more uniform soil temperature, and in this respect it is aided materially by the location of the irrigated area largely under the tree, where it is shaded by the tree top. The plowsole nearly always present in the furrow and cultivation method of treatment also disappears in the mulched basin, and so far no plowsole or equivalent crust has been encountered in basins where an adequate organic mulch has been maintained.

The application of an organic mulch to the basins is followed in some districts by a remarkable increase in the number of earthworms. Earthworms are not often seen in orange or lemon groves under clean cultivation, but in the basins in the Riverside district the soil teems with them; a double handful of soil would often be found to contain a dozen or more worms, and the soil is so riddled with their burrows that when the basin around a tree is filled with water a sea of bubbles appears on the water surface, due to the rapid escape of air from the burrows. The air entrapped below a wet soil surface of fine texture presents a serious obstacle to the further penetration of water unless the soil contains cracks or openings, such as the burrows of earthworms, that are too large to be sealed by the capillary water films. The worms thus appear to have some effect in promoting aeration, and they surely facilitate to a marked degree the penetration of water into the soil. The beneficial effect of the presence of earthworms in the soil has been emphasized by Darwin.

The vigorous root growth taking place in the surface soil under the mulch is very marked in the mulched basins. In the system of dry-soil mulching there is, of course, no root growth in the mulch. and quite often there is very little root growth even to a depth of 8 to 10 inches, owing to the presence of plowsole. Under the mulch in the basins the ground is full of rootlets. The roots have not been observed to penetrate the mulch and are usually not found even in the very rich surface inch of soil. It can readily be seen, however, that any fertilizer applied in these basins soon comes in contact with the root system through the downward movement of the irrigation water and without the necessity of any mechanical incorporation of this material with the soil by cultivation.

Since the mass of fine feeding roots is so near the surface of the soil in the basins, it is absolutely necessary to maintain a mulch that will thoroughly protect this root system, especially during the hot season of the year. A crusting of the surface soil in the basins due to the lack of sufficient mulching material would be very detrimental to the root system.

## FRUIT SETTING AND TREE GROWTH AS INFLUENCED BY THE MULCHING MATERIAL.

### SUNNY MOUNTAIN TRACT.

There was no appreciable difference in the number of fruits picked in the spring of 1914 from the basined trees and the check trees in the Sunny Mountain grove. This shows the uniformity of the two plats.

the fruit having been set in the spring of 1913 before the mulch was applied. In the spring of 1915, however, there was a much heavier set of flowers on the trees basined than on the check trees; but, owing apparently to the effect of cold weather after the fruit had begun to set, the entire district suffered considerably from a heavy drop of the young orange fruits and the unset flowers. On August 23, 1915, a careful count was made of the number of fruits on the trees under the two systems. The fruits at that time were of good size. The number of fruits on the check trees averaged 116 per tree, while the number of fruits on the basined trees averaged 281 per tree, or 2.4 times as many as on the check trees. The quality of the fruit on the basined trees during this season was also superior to that on the check trees, and the fruits were larger and more nearly uniform in size.

### VICTORIA TRACT.

In April, 1915, one row of 33 orange trees in this tract was basined and mulched, one-half of the trees being mulched with alfalfa at the rate of about 1½ bales, or 185 pounds, per basin, and the remainder with cow manure of good quality at the rate of about 20 cubic feet per basin. Some of the basins in each treatment also received 200 pounds of lime, but as no effect of the lime was observable, the discussion will be confined to the mulching materials alone. The basins were circular in form and about 15 feet in diameter, covering an area of about 170 square feet.

There was practically no fruit on these trees in 1915, owing to general deterioration and to a severe scale attack and severe top pruning in the season of 1914–15. On August 12, 1916, 16 months after the installation of the basins, the oranges on each tree were counted. The trees mulched with alfalfa averaged 483 oranges per tree and those mulched with manure 242 oranges per tree. In other words, the trees mulched with alfalfa carried twice as much fruit as those mulched with manure.

The alfalfa mulch was applied to the first eight and the last nine trees in the row and the manure mulch to the intermediate trees. Both ends of the row responded similarly to the alfalfa mulch, not only in fruit setting but in the density and dark color of the foliage as well, the trees showing distinctly the boundary between the two treatments.

At the time the above row (No. 3 in the grove) was basined and mulched an adjoining row (No. 2) was left untreated, and this was furrow irrigated in the usual manner but not cultivated. By August, 1915, row No. 2 was looking so bad that it was decided to basin it. The basins installed were small (about 8 feet in diameter, or 50 to

60 square feet in area) and were mulched with a mixture of hay of different kinds. The trees improved in appearance, but on August 12, 1916, when the counts were made, they were still far from being in as good condition as the trees in row No. 3. On that date the average number of oranges per tree in row No. 2 was 182.

At the time that row No. 3 was basined and mulched the rest of the grove was treated likewise, except that smaller basins, 70 to 80 square feet in area, were installed. These trees improved greatly as compared with trees in certain other adjoining rows which were furrow irrigated in the usual way, but they have not yet come up to row No. 3 either in the appearance of the foliage or in fruit bearing, showing that the larger basins are much more effective.

### EUREKA TRACT.

A test of the relative value of different mulching materials was begun in this tract in October, 1915, on a block of 60 navel-orange trees. The mulching material used included alfalfa, bean straw, bur clover, sweet clover, barley hay, stable manure, and pine shavings. The basins were about 10 by 12 feet in dimensions. Approximately 125 pounds of mulching material was applied to each basin, except in the case of bean straw, which on account of its scarcity at the time was applied at the rate of 75 pounds per basin. The manure was applied at the rate of about 15 cubic feet per basin. Various commercial fertilizers were also applied to some of the trees, but the effect of these substances was not in evidence at the time the oranges were counted.

In August, 1916, 10 months after the mulch was applied, the number of oranges on each tree was determined by counting. Records of the yields of the individual trees in this block had also been kept for the preceding six years by the Office of Horticultural and Pomological Investigations of the Bureau of Plant Industry, which afforded an excellent basis for establishing the relative productiveness of the different trees under the same treatment. To make the results of the mulching experiments directly comparable, the mean yield of each group of trees in 1916 was corrected by dividing the observed count by the ratio of the average productiveness of that group during the preceding six years to that of the whole block for the same period. This eliminates the influence of high or low performance trees. The results of the counts are given in Table IX, together with the relative yield under the various mulching treatments.

TABLE IX.—*Relative yields of oranges with different mulching materials in the basins.*

| Mulching material. | Number of trees. | Yield in 1916. | | |
|---|---|---|---|---|
| | | Average number of oranges per tree. | Corrected on basis of previous performance of trees. | Percentage of mean yield of whole block. |
| Alfalfa hay | 12 | 550 | 532 | 150 |
| Bean straw | 9 | 463 | 460 | 130 |
| Manure | 9 | 358 | 358 | 101 |
| Barley hay | 10 | 280 | 313 | 89 |
| Sweet clover | 9 | 314 | 305 | 86 |
| Bur clover | 5 | 302 | 300 | 85 |
| Pine shavings | 6 | 224 | 217 | 61 |

It is evident from Table IX that the mulching materials tested differ greatly in value. The highest yield of fruit was obtained when alfalfa was used as a mulch, while the bean straw and manure rank next. The quantity of bean straw used, however, was not sufficient to make an effective mulch, and it seems probable that alfalfa and bean straw are of approximately equal value for mulching purposes. The other legumes were much less beneficial than alfalfa and bean straw. The lowest yield was obtained where pine shavings were employed as a mulch. This material effectively protected the basins from evaporation, so that the beneficial action of the other mulching material is clearly attributable to the organic products from the decomposing mulch which are carried into the soil with the irrigation water.

The average number of oranges on the trees basined and mulched with alfalfa hay was 8 per cent greater than the average yield from these same trees during the preceding six years under furrow irrigation and clean cultivation. The other treatments all show a falling off in yield compared with the average yield of the preceding six years. Up to the time the basins were established, the trees had been irrigated by means of furrows between the tree rows. When the basins were established under the trees, the irrigation between the tree rows was discontinued. The excavations of the basins to a depth of 6 to 8 inches necessarily destroyed some of the small feeding roots, and this fact, combined with the discontinuance of the irrigation between the tree rows, forced the trees to establish a new root system during the time that the fruit buds of the 1916 crop were being developed. A decrease in yield accompanied in most instances the redistribution of the root system, and this fact emphasizes the desirability of a gradual transition to the basin system if the entire surface is not basined. Irrigation and cultivation between the basins for the first year following the installation of the basins would help the trees to reestablish their root systems without checking the growth.

The foliage of the trees mulched with alfalfa and bean straw was much denser and darker in color than that of the trees mulched with barley and pine shavings, the latter trees being off color. The trees mulched with sweet clover, bur clover, and manure were intermediate in color and density of foliage.

While the values of the different mulching materials used in this experiment can not be considered to be accurately represented by the results shown in Table IX, their probable relative value is indicated. In view of the corroborative results obtained in the Victoria tract it would appear that alfalfa is decidedly more valuable for mulching purposes than manure. It also appears from these tests that 150 pounds of alfalfa or 15 to 20 cubic feet of manure when applied to an area of about 150 to 170 square feet will provide sufficient mulching material to last one year and maintain an effective mulch during that period.

### REDLANDS TRACT.

A further comparison of the mulched-basin method with furrow irrigation is afforded by a mulched grove near Redlands. This was planted at the same time and with the same stock as an adjoining grove, and the two received uniform treatment for a time, but for a number of years they have been handled independently. In 1913 a grove of 8 acres was basined by the owner and mulched with alfalfa. The basins were small, scarcely including the drip of the trees. Owing to the slope of the land, two basins were necessary for each tree. The furrow rows were seeded to alfalfa at the time the basins were made, for the purpose of supplying mulching material. The amount of alfalfa produced, however, was not even sufficient to maintain a mulch in the small basins, and in the fall of 1915 the alfalfa was plowed up. The seeding of the furrow rows to alfalfa undoubtedly checked the growth of the trees somewhat by limiting the moisture supply. Moisture determinations made immediately after irrigation where alfalfa was growing showed that the irrigation water penetrated only about a foot below the bottom of the furrows.

A 10-acre grove adjoining the 8-acre basined grove has throughout been furrow irrigated and cultivated in the usual manner.

While the basins were established in the 8-acre tract in 1913, their effect on the set and yield of fruit would not be seen until the following year. The average yield of this tract in 1911 and 1913 (1912 being excluded on account of the freeze) was 4.9 boxes per tree, compared with 3.2 boxes per tree on the 10-acre tract.

The average annual yield per tree of the 8-acre tract since the basins were installed has been 5.5 boxes per tree,[1] while the average annual yield of the unbasined trees during the same period has been 3.2 boxes per tree, the same as during the preceding period.

It is not possible to differentiate sharply in this case between the effect of mulching and other factors which led to higher yields from the 8-acre tract previous to mulching. Assuming the 10-acre tract to constitute a fair check, the yield of the 8-acre tract has been increased 12 per cent by the installation of the basins.[2]

## SIZE OF BASINS.

The basins in the Sunny Mountain experimental tract extended to the middle of the furrow row and included the entire soil surface. This type of basin requires the most mulching material and is consequently the most expensive to maintain. In following this plan it is necessary to restrict the basins between every fifth and sixth row of trees sufficiently to provide a roadway to haul out fruit, bring in the mulching material, and distribute fire pots and oil when frost protection is necessary. With this type of basin all of the soil is irrigated and available for the development of the root system of the tree. If all of this soil is not necessary for an adequate root development, then a restricted basin system may be used. Certainly all of the soil is not utilized to the best advantage in the present system of furrow irrigation, for the soil under the tree during the summer is so dry as to make the development of feeding roots practically impossible. From the marked response and increased vigor of the trees under the basin system in the Victoria and Vivienda experimental tracts, where restricted basins were used, it appears that the basins can be reduced somewhat below the maximum area without detriment to the trees and with a corresponding reduction in the cost of maintenance.

With restricted basins, measuring 10 by 20 feet in a grove planted 20 feet each way, a cover crop can also be grown between the tree rows during the rainy months to supply part of the mulching material. The summer growth on these interrow strips, which without irrigation will necessarily be limited, can also be cut and applied to the basins when sufficient in quantity to justify the labor. If extra water is available, these interstrips may be irrigated and the yield of mulching material increased. It is not practicable, however, to attempt to provide all of the mulch in this way.

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[1] This is based upon the yield of only one-half the tract in 1915–16. The remaining portion was seriously damaged through the use of an oil spray for scale in 1915, resulting in a heavy drop of leaves and fruit and reducing the yield of the sprayed portion to less than half that of the unsprayed trees.

[2] The crop on the trees at the present writing (September, 1916) is also much better on the mulched-basin tract than on the adjoining grove, in spite of the fact that the 8-acre tract is badly infested with scale.

In groves planted on contours the form and size of the basins will necessarily be determined by the slope of the land. In such cases two smaller basins will usually be required for each tree, one above and one below the tree in the row. Even in straight-row planting it will often be found advisable to divide the basin at the tree trunk in order to insure adequate irrigation on both sides of the tree. Special precaution should be taken to prevent the soil forming the dikes from being banked against the trunk of the tree. Lemons appear to be particularly susceptible to bark diseases when through low planting or soil washing the moist soil is brought into contact with the trunk above the graft.

## COST OF PREPARING AND MAINTAINING THE BASINS AND THE MULCH.

The initial cost of installing a basin system varies with the soil and with the size of the basins. No exact figures can be given for all the different soil types and basin sizes, but some specific examples can be cited. The cost for labor alone in one grove on a sandy loam soil was about $18 per acre. The basins in this grove were circular and about 8 feet in diameter, and the grove was close planted. The labor cost in other groves on clay-loam soil ranged from $22 to $25 per acre.

The cost of the mulching material varies greatly. At the present writing, manure in carload lots from Los Angeles costs $2.20 per ton delivered on siding in orange districts 50 miles distant. Allowing 15 cubic feet of manure per basin, this would cost approximately 50 cents per tree. One hundred and fifty pounds of alfalfa or bean straw will provide a mulch equivalent to that obtained with 15 cubic feet of manure, and in the experimental plats has given greater returns. The average yield from one block (Victoria grove) of alfalfa-mulched trees was twice that of the manure-mulched trees, while in another block (Eureka grove) the alfalfa-mulched trees carried on the average 50 per cent more fruit than the trees mulched with manure. Barley straw costs less than either alfalfa or bean straw, as a rule, but in the trials here reported it has not proved so desirable a material for use as a mulch, and it contains less nitrogen.

Any mulch lasts well during the summer season, although the under portions undergo decomposition soon after being applied. During the rainy season, however, all kinds of mulching material break up rapidly, and in the course of a year the mulch practically disappears unless a fairly large quantity is used. In general it appears that 150 pounds of alfalfa or its equivalent a year is necessary to maintain a mulch in a basin 150 square feet in area.

The maintenance of the dikes is a small item of expense, and with a furrow along the side of the basins for irrigating each basin separately there should be no upkeep expense for two years at least, and probably the dikes will last longer. It is necessary, however, to use only a small stream of water in filling the basin, especially on land with a steep slope, as otherwise the silt and fine sand brought into the basin will in time fill it, necessitating future excavations, with the loss of a part of the rich soil formed.

The cost of the application of water will probably be greater with the basin system, as it will be necessary to keep a night irrigator on duty during irrigation. On the other hand, there is a marked saving in the quantity of water used and a marked saving through the elimination of teamwork of all kinds in the orchard except for hauling fruit and replenishing the mulching material. The breaking of heavy fruit-bearing branches during cultivation and the injury of fruit from contact with harness or harrow are also avoided.

## LIMITATIONS OF THE MULCHED-BASIN SYSTEM.

The mulched basin is not the solution of all the difficulties of citrus culture. It will probably be found less advantageous on sandy or sandy loam soils than on loam or clay-loam soils. It is not suitable for heavy gumbo soils. Some hand labor (hoeing or mowing) will be required to keep the weed growth in the basins under control and to prevent undue loss of moisture from this source.[1] The organic mulch in the basins will also harbor some gophers, although experience so far indicates that the frequent flooding of the basins discourages them from seeking refuge under the mulch. The proximity of the roots to the surface necessitates the maintenance of an effective organic mulch in the basins for the best results. The cost of suitable mulching material will very greatly depend on the location of the groves and in some cases may seem prohibitive. In this connection it must be remembered that the humus content of some citrus groves has been reduced to such a degree that its restoration by some means appears imperative. The efficiency from the nutrition standpoint of the organic material applied to the surface in comparison with the same material plowed under remains to be determined.

The marked response of citrus trees under the mulched-basin system in the experimental tracts justifies its serious consideration by citrus growers. Its final position in the industry can be determined only after it has been thoroughly tested in comparison with other systems in commercial practice.

---

[1] This plant growth in the basins can, of course, be used to supplement the mulching material.

## HUMUS CONTENT OF THE BASINS AND THE CHECK SOILS.

### SUNNY MOUNTAIN GROVE.

Determinations of the humus content of the soil in the basined area and in the untreated area to a depth of 3 feet are given in Table X. Determinations of humus are necessarily somewhat inaccurate, owing not only to the variation in sampling but also to the fact that humus, so-called, is an indefinite mixture of organic compounds.[1] The Sunny Mountain grove, so far as known, had been treated uniformly previous to the installation of the mulched basins. Composite samples collected in 1914 indicated that the check area contained slightly more humus than the basined area. In the spring of 1915, however, the surface foot of the basined area was higher in humus, as shown in Table XIII. The humus content of the surface foot of soil below the mulch also increased gradually throughout the summer, while the check area, which received no organic material save that contained in commercial fertilizers, showed practically no change. The increase in humus in the basins is confined practically to the first foot of soil. At lower depths the humus content of the two tracts differs but slightly, decreasing gradually to a depth of 6 feet, as shown by the mean values in Table X. If the humus content of the soil is limited, it is advantageous to have it localized largely in the upper 3 feet of soil, which in most California soils includes the principal feeding roots of citrus trees.

TABLE X.—*Percentage of humus in the first and in the second 3 feet of soil in the Sunny Mountain grove, California, in 1915.*

| Depth and date. | Basins near upper end of tract. | | | | Basins near lower end of tract. | | | | Average, both ends of tract. | Furrow system near upper end of tract. | | | | Furrow system near lower end of tract. | | | | Average, both ends of tract. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | First foot. | Second foot. | Third foot. | Average. | First foot. | Second foot. | Third foot. | Average. | | First foot. | Second foot. | Third foot. | Average. | First foot. | Second foot. | Third foot. | Average. | |
| First 3 feet: | | | | | | | | | | | | | | | | | | |
| Apr. 9... | 0.52 | 0.18 | 0.17 | 0.29 | 0.53 | 0.34 | 0.21 | 0.36 | 0.33 | 0.37 | 0.27 | 0.13 | 0.26 | 0.37 | 0.27 | 0.14 | 0.26 | 0.26 |
| June 15. | .63 | .22 | .13 | .33 | .59 | .29 | .13 | .34 | .33 | .32 | .24 | .11 | .22 | .42 | .35 | .17 | .31 | .27 |
| July 10.. | .72 | .26 | .10 | .36 | .63 | .25 | .16 | .35 | .35 | .42 | .18 | .10 | .23 | .29 | .42 | .22 | .31 | .27 |
| Aug. 6.. | .67 | .28 | .14 | .36 | .50 | .23 | .13 | .29 | .33 | .37 | .24 | .17 | .26 | .50 | .44 | .18 | .37 | .32 |
| Sept. 21. | .84 | .16 | .08 | .36 | .67 | .36 | .10 | .37 | .37 | .36 | .20 | .11 | .22 | .37 | .32 | .26 | .27 | .27 |
| Average.. | .68 | .22 | .12 | .34 | .58 | .29 | .15 | .34 | .34 | .37 | .23 | .12 | .24 | .39 | .36 | .19 | .30 | .28 |

---

[1] The humus was determined by removing the calcium with 1 per cent hydrochloric acid, extracting with sodium hydroxid, and measuring the intensity of the humus color against a standard humus solution in a colorimeter. The standard solution was freshly made up by weight from uniform dry stock material obtained by extraction with 4 per cent ammonia after treating with 1 per cent hydrochloric acid and washing free from chlorids. The ammonia extract was filtered through a Pasteur-Chamberland filter before evaporating to dryness.

TABLE X.—*Percentage of humus in the first and in the second 3 feet of soil in the Sunny Mountain grove, California, in 1915*—Continued.

| Depth and date. | Basins near upper end of tract. | | | | Basins near lower end of tract. | | | | Average, both ends of tract. | Furrow system near upper end of tract. | | | | Furrow system near lower end of tract. | | | | Average, both ends of tract. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fourth foot. | Fifth foot. | Sixth foot. | Average. | Fourth foot. | Fifth foot. | Sixth foot. | Average. | | Fourth foot. | Fifth foot. | Sixth foot. | Average. | Fourth foot. | Fifth foot. | Sixth foot. | Average. | |
| Second 3 feet: | | | | | | | | | | | | | | | | | | |
| Apr. 9... | 0.07 | 0.05 | 0.05 | 0.06 | 0.12 | 0.05 | 0.03 | 0.07 | 0.06 | 0.05 | 0.02 | Tr. | 0.02 | 0.07 | 0.04 | 0.03 | 0.05 | 0.04 |
| June 15.. | .09 | .04 | .03 | .05 | .06 | .03 | .03 | .04 | .05 | .05 | .03 | 0.03 | .04 | .13 | .08 | .05 | .08 | .06 |
| July 10.. | .07 | .04 | .04 | .05 | .07 | .04 | .04 | .05 | .05 | .06 | .05 | .04 | .05 | .13 | .11 | .05 | .10 | .07 |
| Aug. 6... | .12 | .05 | .05 | .07 | .08 | .06 | .04 | .06 | .07 | .07 | .05 | .04 | .05 | .18 | .09 | .08 | .12 | .08 |
| Sept. 21. | .08 | .03 | .03 | .05 | .11 | .05 | .03 | .06 | .05 | .06 | .04 | .03 | .05 | .09 | .06 | .06 | .07 | .06 |
| Average.. | .09 | .04 | .04 | .06 | .09 | .05 | .03 | .06 | .06 | .06 | .04 | .03 | .04 | .12 | .08 | .05 | .08 | .06 |

## VIVIENDA GROVE.

Determinations of the average percentage of humus in the first 3 feet of soil in the Vivienda experimental tract are presented in Table XI. Samples taken in October, about four months after the mulch was applied, showed an appreciable increase in the humus content of the soil in the basins. The mulch was carefully removed before sampling, so that only the soil itself was taken up. The percentage increase in humus was about the same in the basins mulched with manure and with alfalfa.

The plat in which the barley was disked showed a marked increase in humus 50 days after the green cover crop was incorporated with the soil. The changes in humus content were all confined to the surface foot of soil.

TABLE XI.—*Average percentage of soil humus to a depth of 3 feet when various treatments were given in the Vivienda grove, California, in 1915.*

| Soil treatment. | June 23. | July 16. | Aug. 9. | Sept. 4. | Oct. 4. | Oct. 30. |
|---|---|---|---|---|---|---|
| Manure: | | | | | | |
| Surface disked | 0.15 | ........ | 0.16 | 0.14 | (1) | ........ |
| Same, plus lime | .19 | ........ | .20 | .16 | (1) | ........ |
| In basins | .15 | ........ | .12 | .15 | 0.18 | 0.21 |
| Same, plus lime | .18 | ........ | .16 | .19 | .24 | .31 |
| Alfalfa: | | | | | | |
| In basins | .12 | ........ | .13 | .13 | .24 | .20 |
| Same, plus lime | .18 | ........ | .13 | .19 | .30 | .26 |
| Sweet clover: | | | | | | |
| Disked in about August 15 | .14 | ........ | .15 | .13 | (1) | ........ |
| Same, plus lime | .22 | ........ | .21 | .23 | (1) | ........ |
| Barley: | | | | | | |
| Disked in July 16 | .16 | 0.16 | ........ | .25 | (1) | ........ |
| Same, plus lime | .18 | .17 | ........ | .25 | (1) | ........ |
| Disk cultivated | .16 | ........ | .15 | .19 | (1) | ........ |
| Same, plus lime | .22 | ........ | .16 | .19 | (1) | ........ |

(1) Basined.

### VICTORIA GROVE.

The percentage of humus in the soil in the Victoria grove under the various treatments is shown in Table XII. Here again the humus did not increase perceptibly in the basins until October, 112 days after the initial samples were taken. The low initial humus content in the basins is due in part to the removal of the surface soil in making the basins. The manure and alfalfa were equally effective in increasing the humus percentage up to the time of the last sampling.

TABLE XII.—*Average percentage of soil humus to a depth of 3 feet when various treatments were given in the Victoria grove, California, in 1915.*

| Soil treatment. | June 22. | Aug. 13. | Sept. 13. | Oct. 12. |
|---|---|---|---|---|
| Alfalfa: | | | | |
| In basins | 0.073 | 0.073 | 0.075 | 0.084 |
| Same, plus lime | .134 | .106 | .147 | .156 |
| Manure: | | | | |
| In basins | .136 | .130 | .136 | .153 |
| Same, plus lime | .150 | .112 | .139 | .160 |

## SUMMARY.

Mottle-leaf of citrus trees is characterized by yellowish spots or blotches on the leaves and by a reduction in the size of the leaves and the density of the foliage. In its advanced stages it results in a marked reduction in yield and in the size and quality of the fruit. No fungus or bacterium has yet been found to be causally associated with this trouble.

Work carried out by the writers in 1914 and reported in another paper showed that half of the mottling in about 120 orange groves in the Riverside, Redlands, Rialto, and Highland districts of California was associated with a low humus content of the soil. Evidence was also secured which indicated that inadequate irrigation might be responsible in part for the development of mottle-leaf.

The present paper is concerned with field experiments relating to the irrigation of oranges and the use of organic fertilizers and deals particularly with a new method of citrus culture, the mulched-basin system, in which low dikes are thrown up so as to form large shallow irrigation basins near each tree, and each basin is heavily mulched with alfalfa hay, bean straw, manure, or some other organic material. The basin makes it possible to supply each tree with water in accordance with its needs, while the water carries with it to the feeding-root system the plant food extracted from the disintegrating mulch.

The system of furrow irrigation and clean cultivation in common use in citrus districts in California tends to promote the formation of a plowsole, or incipient hardpan, below the surface mulch, varying in thickness from 3 inches to 2 feet; leads to excessive accumulations of soluble plant-food substances, especially nitrates, at the surface of the soil, where they remain until washed down by the winter rains; and fails to conserve the soil moisture sufficiently to prevent the trees from wilting frequently during the summer months.

The mulched-basin system was found to conserve the soil moisture better than any other system of soil treatment compared with it, and none of the basined trees on either light or heavy soils wilted. Under all the other cultural methods employed wilting occurred at some period during the summer on both light and heavy soils.

Available soil moisture below the third foot did not prevent orange trees from wilting if the moisture content in the first 3 feet of soil fell below the wilting coefficient.

With the amount of irrigation water ordinarily available in these districts (1 miner's inch to 4 or 5 acres) cover crops of barley or sweet clover can not be grown during the summer months in groves on either heavy or light soils without causing the wilting of the orange trees.

Circular trenches dug around orange trees, filled with manure or alfalfa and covered with dirt, did not remain open sufficiently after the second irrigation to distribute the irrigation water adequately.

In the clay-loam soils of the type constituting the Victoria area the lateral movement of moisture is very slight. In such soils the furrow system of irrigation is inadequate unless a large number of furrows are used, including furrows under the trees.

Moisture determinations in groves in which alfalfa was being grown as a permanent cover crop show that the irrigation water never penetrated deep enough into the soil to insure an adequate moisture supply for the orange trees.

For a basin having an area of 150 square feet the experiments indicate that approximately 150 pounds of alfalfa or 15 to 20 cubic feet of stable manure will be required each year to maintain an effective mulch.

It is not possible with the water ordinarily available to grow mulching material between the basins sufficient to maintain a satisfactory mulch on the basins. Cover crops, however, can be grown between the basins on winter rainfall to supply part of the mulch, and where water is available in the summer it can be used for the same purpose.

Orange trees on clay-loam soil, such as the Victoria soil, responded more quickly to the mulched-basin system than trees similarly treated on light soils, because the heavier soils under the furrow method of irrigation do not absorb moisture as rapidly as lighter soils. Mulched-basined trees on clay-loam soils showed a marked response to the treatment in 3 months, while basined trees on light soils required from 6 to 12 months to show a growth superior to that obtained with furrow irrigation and clean cultivation. The mulched basin is not satisfactory on heavy gumbo soils.

The set of fruit was very light throughout the Riverside district in 1915, owing apparently to cold weather following the bloom. In the Sunny Mountain tract, where the mulched basins were first installed in 1913, the average number of oranges per tree on the check trees in 1915 was 116, while on the mulched-basin trees the average number of oranges per tree was 281, or two and one-half times as many as on the check trees. The quality of the fruit on the basined trees was also superior to that on the unbasined trees. In the Victoria tract in 1916 the alfalfa-mulched trees averaged 483 oranges, the manure-mulched trees 242 oranges, and the check trees 182 oranges. In the Eureka tract, where the mulched basins had been installed the preceding autumn, the alfalfa-mulched trees carried on the average 550 oranges, an increase of 33 oranges per tree over the average yield of these trees for the preceding six years. Experiments in this tract with other mulching materials showed a decrease in yield during the first season, due in part at least to the fact that the new root system below the basins was not established at the time the fruit buds were set.

The new leaf growth on the basined trees was less mottled than the new growth on the unbasined trees after sufficient time had elapsed for the mulched-basin system to produce response in the tree growth.

The new leaves on the basined trees were larger and darker in color and had a better texture than those on the unbasined trees, especially on heavy soil.

The new growth of rootlets under the mulch in the basins was very much greater than in the check treatments, the soil in the basins being filled with rootlets to within about 2 inches of the surface.

Great numbers of earthworms were often found in the basins under the mulch, and their burrows honeycombed the entire soil mass. The worms help to incorporate the organic material with the soil, while their burrows facilitate the absorption of water in heavy soils.

No soil crust of any kind has been found in the basins where the mulch completely covered the soil surface. A complete mulch must be maintained at all times, however, to prevent the surface from crusting.

The experiments indicate that alfalfa and bean straw are superior to stable manure for mulching purposes.

In the mulched basins the quantity of humus, as measured by the intensity of the color of the alkaline extract, increased markedly in the first foot of soil during the summer, but no increase was observable at the greater depths. From 70 to 120 days were required for the mulch in the basins to decompose sufficiently to produce a measurable increase in the humus content. Alfalfa and manure mulches were equally effective in producing this increase in humus. Barley cover crops produced a marked increase in the humus content of the soil 50 days after being disked into the soil.

The use of an organic mulch moderates the rise in soil temperature during the day. The advantages of the mulch, however, are not wholly attributable to this fact nor to the conservation of moisture. Wood shavings when used as mulching material afforded as much protection in this respect as alfalfa or bean straw, yet trees mulched with pine shavings gave yields less than half those obtained with mulches of alfalfa or bean straw.

Surface mulching with organic material, especially when available in quantities sufficient to cover the entire surface, may in the long run prove fully as effective as the use of the mulching material in basins. A more immediate response from the mulched basin may be expected, however, owing to the fact that each time the basins are flooded the soluble portions of the decaying mulch are carried with the irrigation water directly into the soil. In this respect the mulched basin resembles a surface organic mulch in humid regions where the rainfall first passes through the mulch before entering the soil. Many of the citrus soils of California contain so little active organic matter that it is essential to secure the advantages of the applied organic material at the earliest possible date, and this appears to be brought about more quickly by the use of the mulched basin than by organic mulches with furrow irrigation. The mulched basin also appears to be the most effective means of using a limited quantity of mulching material.

The marked response of citrus trees in the experimental tracts under the mulched-basin system justifies its serious consideration by citrus growers. It is still in the experimental stage, and its suitability to local conditions in any instance should be thoroughly tested in an experimental way before installing basins on a large scale. Its final value in the industry can be determined only after it has been so tested in comparison with other systems in commercial practice.

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W. J. SPILLMAN, Chief

Washington, D. C. ▼ March 14, 1917

# THE COST OF PRODUCING APPLES IN WESTERN COLORADO

## A DETAILED STUDY, MADE IN 1914-15, OF THE CURRENT COST FACTORS INVOLVED IN THE MAINTENANCE OF ORCHARDS AND THE HANDLING OF THE CROP ON 125 FARMS IN THE FRUIT REGIONS OF MESA, DELTA, AND MONTROSE COUNTIES

By

**S. M. THOMSON, Scientific Assistant, and**
**G. H. MILLER, Assistant Agriculturist**

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# THE COST OF PRODUCING APPLES IN WESTERN COLORADO.

## A Detailed Study, Made in 1914-15, of the Current Cost Factors Involved in the Maintenance of Orchards and the Handling of the Crop on 125 Farms in the Fruit Region of Mesa, Delta, and Montrose Counties.

By S. M. Thomson, *Scientific Assistant*, and G. H. Miller, *Assistant Agriculturist*.

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The study of apple production discussed in this bulletin was made during the years 1914 and 1915 in the Grand Valley and adjacent districts of western Colorado.[1] This area was chosen as being representative of a region which is not only of great present commercial importance, but has a large acreage of young orchards not yet in bearing.

The Grand Valley district (see fig. 1) is primarily one of specialized fruit farming; in Delta and Montrose counties, also covered by the survey, the farming is more or less diversified. The region as a whole is one of the important centers of box-apple production, competing with the orchards of the Middle West and supplying a large part of the fruit which goes to the Texas trade. All apples are grown under irrigation, principally on comparatively small farms.

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[1] This is the second of a series of bulletins designed to give comparative and comprehensive information on the different methods of orchard management in vogue in different apple-growing districts and in regard to the several factors which enter into the cost of apple production. The first of these bulletins, dealing with Wenatchee Valley, has been published as Department Bulletin 446.

NOTE.—Acknowledgments are due to the Office of Pomological and Horticultural Investigations of the Bureau of Plant Industry for material assistance rendered in the prepararion of this bulletin.

The data here presented were obtained through detailed studies of the orchard practices of 125 representative apple growers, 49 of whom were located in Mesa County, 61 in Delta County, and 15 in

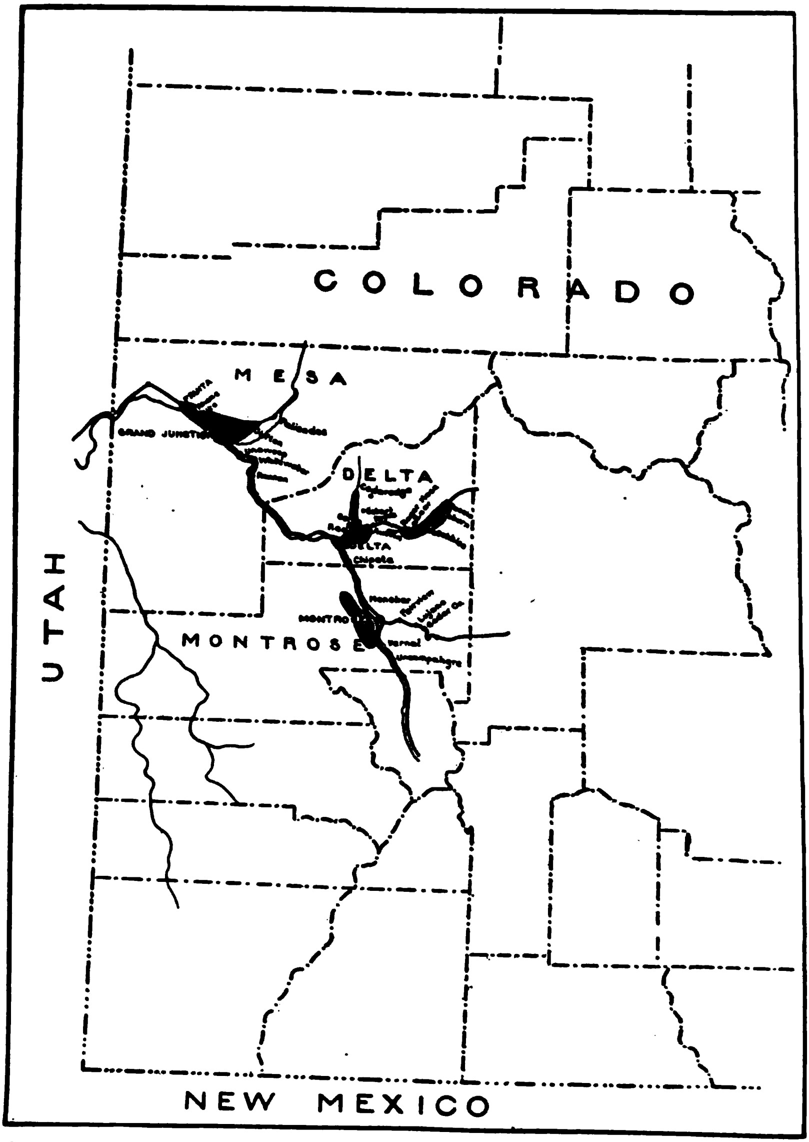

FIG. 1.—Map showing location of the western Colorado fruit districts (shaded areas) where the investigation was conducted.

Montrose County. Orchards were chosen with a view to getting a representative average, extremes in size being avoided and effort being made to pick only such as were fairly comparable in acreage and development. Data were secured from each grower as to the time required for each operation, as to equipment, cost of labor, spraying materials, boxes, etc., and as to land and orchard values.[1]

The factors considered in arriving at the annual cost of apple production have been classified as follows:

| Labor. | | Costs other than labor. | |
|---|---|---|---|
| **Maintenance.** | **Handling.** | **Material costs.** | **Fixed costs.** |
| Manuring.<br>Pruning.<br>Disposing of brush.<br>Plowing.<br>Cultivating.<br>Irrigating.<br>Thinning.<br>Spraying.<br>Miscellaneous. | Hauling box shooks.<br>Making boxes.<br>Hauling loose boxes out.<br>Picking.<br>Hauling full boxes in.<br>Sorting.<br>Packing.<br>Nailing.<br>Other packing labor.<br>Haul to station. | Box shook.<br>Nails.<br>Paper.<br>Labels.<br>Spray materials.<br>Manure.<br>Gasoline, oil, etc. | Taxes.<br>Insurance.<br>Water rent.<br>Equipment charge.<br>Machine hire.<br>Interest.<br>Building charge. |

## FACTS BROUGHT OUT.

It was found that the total cost of production[2] for the 125 farms representing the entire region averages $0.844 per box; for Mesa County (Grand Valley), $0.935; for Delta County, $0.795; for Montrose County, $0.767. (See Table I.)

Labor costs average $0.394 per box and $111.88 per acre (46.7 per cent of total cost).

Material and fixed costs (manure, spray materials, boxes, water rent, interest on investment, taxes, insurance, etc.) average $0.45 per box and $127.91 per acre (53.3 per cent of total cost). Of this cost the principal item is interest on investment in orchard, which is $0.184 per box, or 21.8 per cent of the total cost.

---

[1] It is of vital importance that the method of computation used in this study be fully understood at the outset; otherwise confusion and misapprehension will be inevitable. It should be borne in mind constantly that the primary result desired is a figure representing fairly the average regional cost of apple production—that is, the cost in its relation to the apple business of western Colorado as a whole. To get such an average it is often necessary to use certain averages which in themselves have no agricultural significance, which have no weight except as they contribute to the determination of the regional average. For example, the average acre cost of manuring for the entire acreage of the district under consideration is represented by a figure too small to have significance as applied to any one ranch, since not all the ranches practice manuring, but which has an economic significance with reference to the business of the district as a whole. For the purposes of this study it is as though the entire region were one farm and the cost per acre for manuring were distributed equally over the whole farm acreage rather than over the particular part of the farm upon which the manure happens to be applied. This method gives an average that may mean nothing as applied to the single operation of manuring, but which may mean much as applied to the business of growing apples in the region studied. To arrive at the result desired in this study, namely, the cost of producing apples as borne by the district as a whole, each orchard operation has been figured against the total number of farms. In this way a regional acre charge is determined for each operation, the acre being used as the unit, so that each orchard, regardless of size, may have the same weight in the final calculation. Thus, so far as these calculations are concerned, each of the 125 orchards involved may be considered as being but one acre in extent. In this way weighted averages are avoided, and the final average cost per box becomes a fairly accurate approximation of the actual cost of producing apples in the region, as represented by the 125 ranches chosen as typical of western Colorado conditions.

It was thought advisable in this connection to figure separately the costs for each county, as well as for the whole region, as the three districts differ greatly in the factors materially affecting cost. Thus the figures may be compared and the results studied in their bearing upon types and systems of farming, which differ quite widely in the three counties.

[2] Not including orchard depreciation and cost of smudging, omitted for lack of sufficient data.

The average yield for the district is 284 boxes per acre; 3.8 per tree. Average yield in Grand Valley, 275 boxes per acre; in Delta County, 294; in Montrose County, 272.

TABLE I.—*Summary of all costs entering into the annual cost of production of apples (125 ranches, western Colorado).*

| | Maintenance cost. | | | Handling cost. | | | Material costs. | | | Fixed costs. | | | Total costs. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per acre. | Per box. | Per cent of total. | Per acre. | Per box. | Per cent of total. | Per acre. | Per box. | Per cent of total. | Per acre. | Per box. | Per cent of total. | Per acre. | Per box. | Per cent of total. |
| Mesa | 67.77 | 0.247 | 26.4 | 48.24 | 0.176 | 18.82 | 58.25 | 0.212 | 22.67 | 82.51 | 0.300 | 32.09 | 256.77 | 0.935 | [illegible] |
| Delta | 50.57 | .171 | 21.5 | 59.42 | .202 | 25.41 | 56.14 | .191 | 24.02 | 67.83 | .231 | 29.06 | 233.96 | .795 | [illegible] |
| Montrose | 47.64 | .176 | 22.9 | 58.66 | .216 | 28.16 | 50.78 | .187 | 24.38 | 51.27 | .188 | 24.51 | 208.35 | .767 | [illegible] |
| District | 56.94 | .201 | 23.8 | 54.94 | .193 | 22.87 | 56.32 | .198 | 23.46 | 71.59 | .252 | 29.85 | 239.79 | .844 | [illegible] |

The trees in orchards studied average 17 years of age and 74 to the acre.

Jonathan is the leading variety, with Ben Davis, Rome Beauty, Gano, and Winesap following, each of about equal importance.

## CONCLUSIONS DRAWN.

Averages secured in this study seem to warrant the following conclusions as to fruit farming in the Grand Valley and adjacent districts:

The majority of farms are not sufficiently diversified to secure the best results.

The farms studied were prosperous in direct proportion to the degree of diversification practiced.

Care must be taken in setting orchards to pick suitable soil and an area well drained and not subject to seepage.

Clean cultivation can not be practiced indefinitely without depleting the soil seriously. Humus should be supplied either in the form of manure or by using cover crops.

Manure is of very great value as an orchard fertilizer.

In general it seems inevitable that fruit growers must find important supplemental sources of income to tide them over years of low fruit prices. This is a rich country, with the advantage of a delightful climate, a naturally fertile soil, and an excellent class of progressive settlers, and it is capable of becoming a region of well-established general farming. Certain limited areas of the region are particularly well adapted to fruit growing; for example, the fruit ridges about Grand Junction and some of the mesa land in Delta County not subject to frost. Much of the region is not adapted to specialized fruit farming, and it is probable that fruit growing combined with general farming will be more successful financially than fruit growing alone.

## HISTORY OF APPLE INDUSTRY.

In Mesa County the Indians occupied the Grand Valley until 1880, when they were moved into Utah. The history of fruit growing in western Colorado begins about this time. In the spring of 1883 several thousand root grafts were put out in the Grand Valley on some leased land by a Denver nurseryman, but only a fraction of the original root grafts were saved when later a more favorable location was selected for the nursery.

The first trees were set on Oldham bottoms and the lower lands of the valley. The first fruit on Fruit Ridge was set in 1885 and 1886. The plantings gradually extended from here down the valley to Fruita, but it was not until the early nineties that fruit began to be set at all extensively. By about 1900 the industry became extremely popular and land began to rise very rapidly in price. In 1900 the price of land in Grand Valley under good water rights ranged from $200 to $300 per acre. In 1907 and 1908, when prices reached their maximum, land sold from $600 to $700 per acre, while good apple orchards often sold for $1,000 or more per acre. During the period of 1900 to 1910 settlers from the Middle West and East came to the Grand Valley in great numbers. In more recent years, however, the influx has not been so great.

The history of the apple industry of Delta County is more or less correlated with that of Mesa. The first fruit of Delta County was set out about 1882, when a grower at Paonia procured 26 trees of mixed varieties from Rochester, N. Y., at $1 each. Of these 3 survived shipment. A few other pioneers began to plant trees about this time or shortly after. The industry developed rapidly in this county but on a somewhat less speculative basis than in the Grand Valley.

In Montrose County, where farming is of a comparatively general type, the fruit industry dates from about 1882. Many orchards were set in the early nineties on Spring Creek Mesa and the plantings continued until about 1909 or 1910. This region developed on a basis different from that of the apple regions of the other two counties in that fruit did not occupy so large an area of each farm and hence in years of low fruit prices did not suffer from lack of diversification in farm business.

## TOPOGRAPHY.

The part of Mesa County considered in this survey, or the region known as the Grand Valley, has been carved out of a high plateau region of sedimentary rocks. The surface of the valley varies, but in the valley proper it is fairly level, requiring comparatively little labor for irrigation. (See Pl. I.)

The fruit of Delta County is located on many mesas and small districts which differ greatly in their facilities for irrigation. Most of the fruit, however, is on level mesa areas, varying in size from several thousand acres to a few hundred. (See Pl. II.) The fruit of Montrose County is also on mesa lands easy to irrigate.

## SOILS.[1]

Most of the orchards of Grand Valley are located on the Billings fine sandy loam. This is a light-gray to brown soil, easily cultivated when moist, but when dry tending to bake and hard to restore to good tilth. This is the principal soil on which fruit and other crops are grown from Palisades to Fruita. In general its drainage is good, but owing to the use of an excess of water, seepage has occurred in many places.

In the immediate vicinity of Fruitvale Station and in rather large areas near the lower levels above the river soils is found the Billings silt loam type, a heavy, sticky, and plastic soil underlain by clay or clay loam. Much of this type has gone to seep and is no longer under cultivation. It is not well adapted to fruit.

The Billings clay loam, a plastic, compact loam, varying from light gray to dark brown in color and very difficult to cultivate when dry, occurs principally in a few areas between Grand Junction and Fruita. Much of it has been affected with alkali. It seems particularly adapted to alfalfa.

The Mesa fine sandy loam, a light and easily cultivated soil requiring considerable water for irrigation, makes up a large part of the soil of the valley, especially that reached by the recently opened Highline Canal. On account of its general high-lying position and its leaching qualities it is well drained. It is adapted to fruit and other crops.

The Mesa clay loam, a reddish to chocolate-brown loam rather difficult of cultivation, is a productive soil adapted to fruit lying principally along the south side of the Grand River. This is the soil of the large mesa known as Orchard Mesa.

The Fruita fine sandy loam is a good fruit soil, but has very poor drainage, so that many of the orchards about Fruita have died from the effect of excessive alkali.

Generally speaking, the soils on which most of the thrifty apple orchards of Grand Valley are located are the Billings and Mesa fine sandy loams. The Mesa clay loam on Orchard Mesa is one of the best of fruit soils.

Nearly all the orchard lands of Delta and Montrose counties are located on Mesa clay loam. In most cases there is enough slope to prevent danger from the rise of alkali. This type of soil is well adapted to alfalfa, wheat, oats, sugar beets, and fruit. No soil survey has been made of the Paonia and Hotchkiss districts, but the fruit here is located on mesa lands with soil of the same general type as the Mesa clay loam.

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[1] Soil survey of Grand Junction area, J. G. Holmes and T. D. Rice; soil survey of The Uncompahgre Valley area, J. W. Nelson and L. A. Kolbe.

## CLIMATE.

The climate of this region on the whole is semiarid, with marked seasonal ranges in temperature and great variation in season, due largely to altitude, which ranges from 4,575 feet above sea level at Grand Junction to 6,100 feet at Cedaredge, in Delta County.

The maximum precipitation is about 11 inches; minimum, 6 inches. This amount of precipitation supports only sparse native vegetation. Crops depend entirely on irrigation. An admirable feature of the climate is its very low humidity. Destructive windstorms are uncommon, but the more elevated regions are subject to destructive local hailstorms.

The topographical features of the region have a marked influence upon the occurrence of killing frosts. Often a difference in elevation of 100 feet or even less is enough to save an orchard from frost. Air currents and "pockets" also have a decided influence. Certain small areas are nearly always subject to damage by frosts. In locating an orchard it is well to pay particular attention to records of frost damage in previous years.

Table II shows climatic data for this region as compared with other important apple districts of the United States. It should be stated in this connection that the weather stations for these various places often are not located in the same locality, or on the same elevation as the orchard; hence the figures are not necessarily a true guide to weather conditions affecting the orchards.

**Table II.**—*Climate of western Colorado and other apple districts of the United States.*[1]

| Station. | Altitude. | Mean annual rainfall (normal). | Mean annual temperature (normal). | Number of clear days. | Number of rainy days. | Average date of last killing frost in spring. | Average date of first killing frost in autumn. | Average number of growing days. |
|---|---|---|---|---|---|---|---|---|
| Western Colorado: | *Feet.* | *Inches.* | °*F.* | | | | | |
| Grand Junction | 4,602 | 8.3 | 52.5 | 170 | 84 | Apr. 18 | Oct. 18 | 188 |
| Fruita | 4,510 | 10.22 | 49.7 | 182 | 63 | May 3 | Oct. 4 | 154 |
| Delta | 4,965 | 7.76 | 49.7 | 225 | 54 | May 11 | Sept. 27 | 139 |
| Paonia | 5,694 | 13.22 | 49.6 | 130 | 81 | May 1 | Oct. 10 | 162 |
| Montrose | 5,811 | 9.58 | 47.5 | 168 | 86 | May 21 | Sept. 28 | 130 |
| Other important apple districts in United States: | | | | | | | | |
| North Yakima, Wash.[2] | 1,070 | 6.64 | 51 | 189.8 | 56.6 | Apr. 18 | Oct. 22 | 187 |
| Payette, Idaho | 2,159 | 11.41 | 50.8 | 168 | 63 | May 9 | Sept. 30 | 144 |
| Hood River, Oreg | 300 | 34.65 | 50.1 | 161 | 90 | Apr. 22 | Oct. 14 | 175 |
| Medford, Oreg | 1,425 | 14.57 | 54.5 | 160 | 114 | Apr. 30 | Oct. 6 | 159 |
| Watsonville, Cal | 23 | 23.85 | 57.3 | 139 | 80 | Mar. 17 | Nov. 1 | 229 |
| St. Joseph, Mo | 967 | 33.21 | 54.7 | 159 | 87 | Apr. 17 | Sept. 26 | 162 |
| Brockport, N. Y | 537 | 35.44 | 47.2 | 115 | 143 | May 2 | Oct. 13 | 164 |

[1] Taken from U. S. climatology records for past 15 years.

[2] North Yakima data taken for years 1910 to 1914 inclusive.

## DISTANCE FROM MARKET.

The Grand Valley is a long distance from market. This, coupled with the fact that fruit products are perishable, makes the marketing question one of prime importance here. In the early years of the industry, when the tonnage of fruit was light and the prices high, the cost of marketing was given little thought. Orchards were set out with slight regard to distance from railroad, for as long as such high prices prevailed the growers could afford to pay hauling charges and high freight and express rates. However, with prices received of late years the cost of putting the apples into the consumers' hands in some cases has been greater than the total returns.

Formerly the mines at Aspen and other mining towns paid high prices for all fruit, both boxed and culled, and Colorado boxed apples brought big returns in city markets, Colorado Springs and Denver then being the principal cities of importance in which the fruit was marketed. Now, however, the disadvantage under which the region labors as regards distance from market is being felt, and adjustments in farm practice have been found necessary. Such adjustments are now going forward.

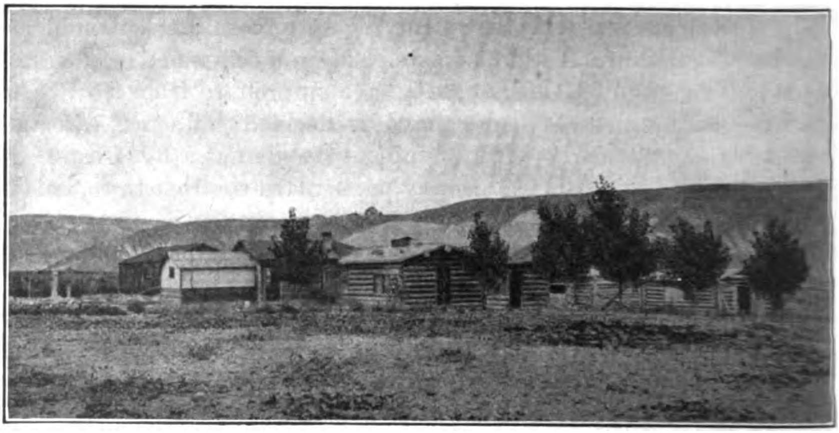
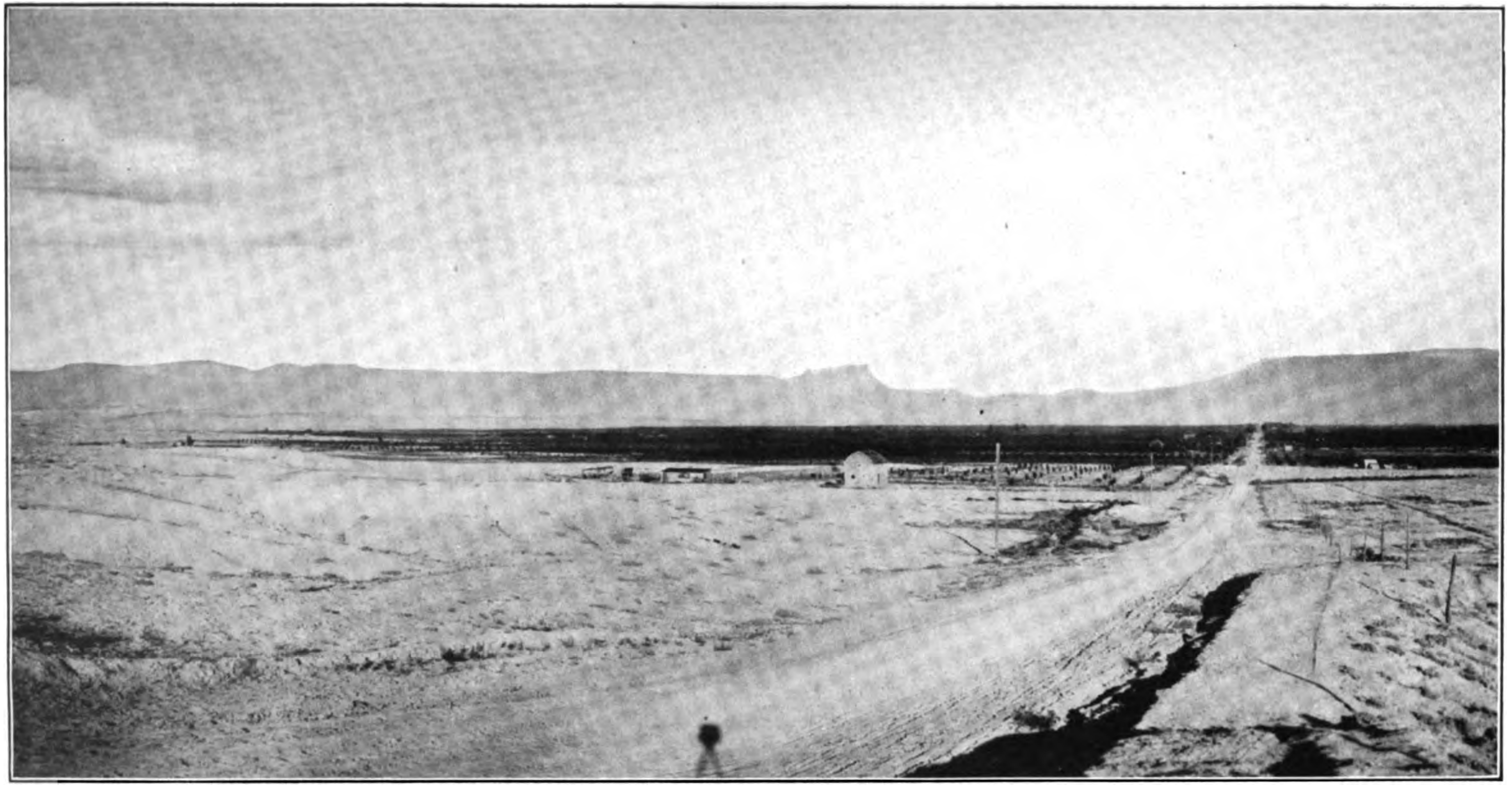


FIG. 2.—A comparatively inexpensive but comfortable home of a fruit rancher located on one of the mesa lands in Delta County.

## FARM ORGANIZATION.

### RELATION OF ORCHARD TO FARM ORGANIZATION.

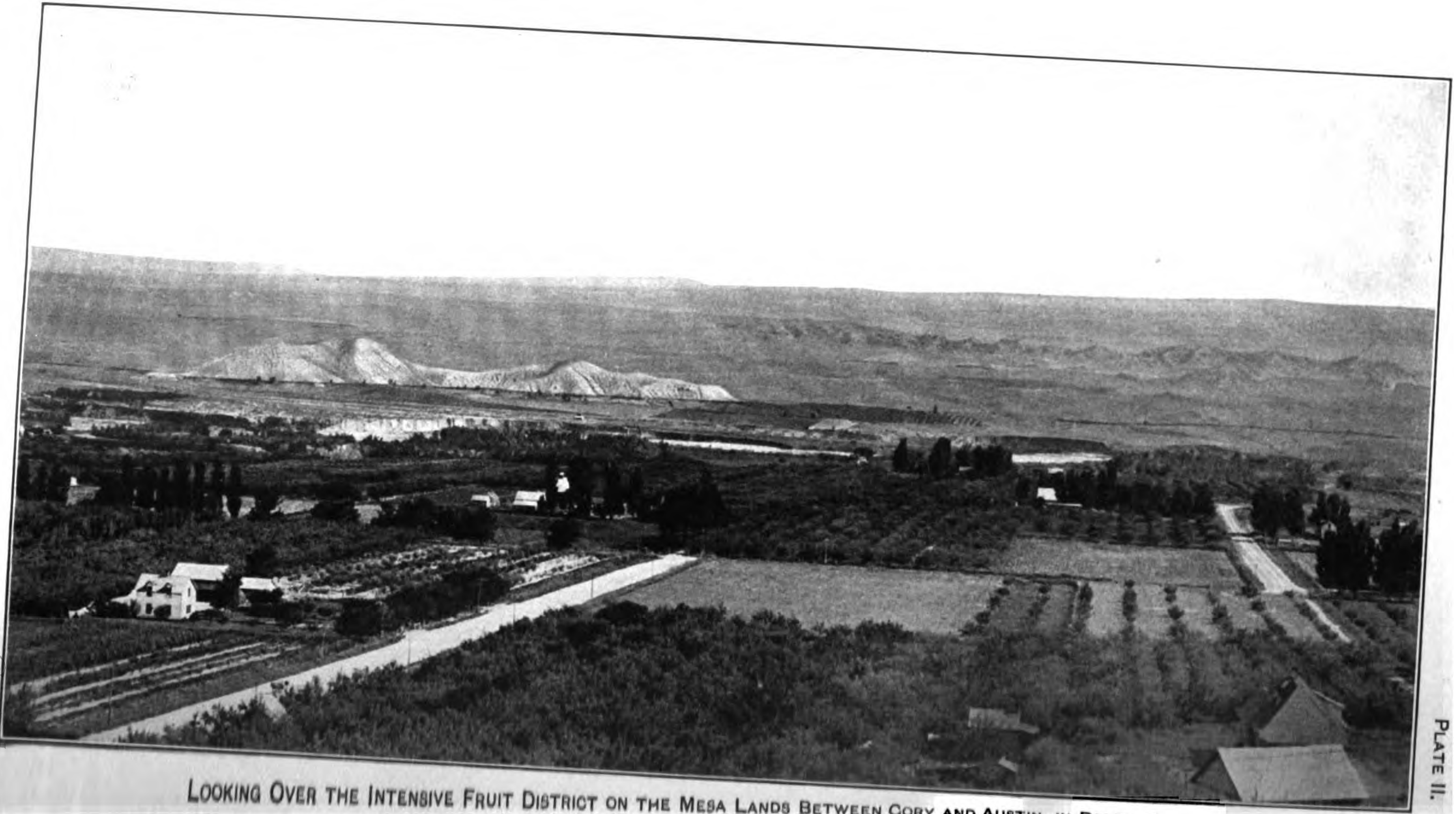
Even in specialized apple districts there are few farms or ranches where bearing apples are the only source of income, and where the cost of producing apples is the cost of operating the farm. Most growers have, besides a bearing apple orchard, a considerable acreage of other orchard, usually young apples, or it may be peaches or pears. Still others grow some alfalfa to sell and, in Montrose County particularly, considerable quantities of grain and potatoes are grown



A TYPICAL LANDSCAPE VIEW OF THE GRAND VALLEY, SHOWING ORCHARDS IN THE CLIFTON DISTRICT AND IN THE DISTANCE THE RANGE WHICH PROTECTS THE UPPER GRAND VALLEY FROM FROSTS.

Note the sharp contrast between desert and cultivated land.

PLATE II.



LOOKING OVER THE INTENSIVE FRUIT DISTRICT ON THE MESA LANDS BETWEEN CORY AND AUSTIN, IN DELTA COUNTY.

for sale. In the case of a young orchard the expense necessary to keeping it up is, of course, chargeable to the young orchard and does not enter into the cost of production of apples from a bearing block.

On the farms situated in Mesa County there is an average of 3.5 acres of young apples per ranch as compared to 8.22 acres of bearing apples; in Delta, 4.94 acres young and 12.19 bearing, and in Montrose, 3.56 young and 13.66 bearing. Furthermore, but 42 per cent of the farm acreage of the ranches surveyed in the Grand Valley is in bearing apples, 23.5 per cent in Delta, and 31 per cent in Montrose. Ninety-two per cent of the total area of the ranches surveyed in Mesa is tillable, 73 per cent in Delta, and 90 per cent in Montrose. A few farms were found where the cost of operating the farm was the same as the cost of producing the apples from the bearing block. In such cases all labor, both man and horse, is charged to the orchard.

Under such specialized conditions there are always long periods of enforced idleness for horse labor and often for man labor, especially where help is hired by the month. By growing alfalfa or annual crops adapted to the region, together with hogs or poultry, a more profitable distribution of labor may be secured.

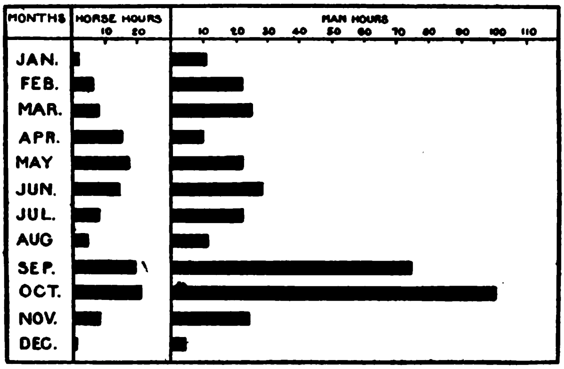


FIG. 3.—Chart showing the average distribution of man and horse labor on an acre of bearing orchard throughout the year.

### SIZE AND TYPE OF FARM.

Table III shows the average size, tillable area, and orchard acreage of the farms studied. The fact that these farms in most cases are small is principally due to the system of land development. In many cases land was bought up, set to fruit, and held for speculation at prices such that the average investor desiring a home could not afford to buy many acres. In fact, it was believed more desirable to have a small, intensive, specialized farm than a larger and more diversified one. In days of high fruit prices this belief was justifiable for the time being, but no provision was made for the day of low fruit prices.

TABLE III.—*Average size of farms and orchards (125 ranches, western Colorado).*

| | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Number of records | 49 | 61 | 15 | 125 |
| Average acreage of farms | 19.56 | 51.86 | 43.86 | [illegible] |
| Tillable acres per farm | 18 | 37.34 | 39.47 | [illegible] |
| Per cent of farm area tillable | 92 | 72 | 90 | [illegible] |
| Average acreage of bearing orchards | 8.22 | 12.19 | 13.66 | [illegible] |
| Average acreage of young apple orchards | 3.5 | 4.94 | 3.56 | [illegible] |
| Per cent of farm area in bearing apple orchards | 42 | 23.5 | 31 | [illegible] |

The farms are most highly specialized in Mesa, less so in Delta, and least in Montrose. Crops besides tree fruits grown for sale include a few truck crops, small fruits, potatoes, alfalfa, small quantities of alfalfa seed, and a little grain. Potatoes are a very important crop in Montrose and parts of Delta County. Most of the grain grown for sale comes from Montrose. Very little stock is kept on the farms surveyed, although on many of the larger ranches of the region stock is fed during the winter and the manure returned to the land. Mesa County (Grand Valley) is very highly specialized, and devoted almost exclusively to fruit, differing in this respect from the other two counties.

### INVESTMENTS.

The amount of capital invested in the fruit farming of western Colorado as compared to other types of farming is very great. The average total investment of the 49 farms in the Grand Valley, averaging 19.56 acres in size, is $12,004.02; the average total investment per acre of these farms, giving each farm the same weight, is $778.32. On these same farms the average bearing apple-orchard investment per farm is $5,826.04, and the average acreage of apples 8.22 acres, or 42 per cent of the average total farm area. However, the average investment per acre on these orchards, giving each orchard, large or small the same weight, is $751.56. The interest charge per acre is figured on this average. (See Table IV.)

The equipment investment per farm as shown in Table IV includes no stock, either horses or cattle, but includes all machinery and other equipment necessary. For the size of farm this is a high investment, due largely to the diversity of tools that are found on these ranches.

TABLE IV.—*Farm and orchard investments (125 ranches, western Colorado).*

| | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Investment per farm: | | | | |
| Total | $12,004.02 | $19,781.23 | $16,733.78 | [illegible] |
| In land and improvements | 11,861.98 | 18,238.79 | 14,914.28 | [illegible] |
| In bearing apple orchard | 5,826.04 | 7,414.74 | 6,292.85 | [illegible] |
| In equipment | 751.56 | 627.38 | 439.28 | [illegible] |
| Investment in bearing apple orchard per acre: | | | | |
| Total | 603.02 | 719.37 | 1,006.92 | [illegible] |
| In equipment | 36.00 | 24.00 | 31.16 | [illegible] |
| Per cent of farm investment in bearing apple orchard: | | | | |
| Total | 48.5 | 37.48 | 37.6 | [illegible] |
| Land and buildings | 49.11 | 40.6 | 42.19 | [illegible] |

Even assuming that the buyer of a ranch has paid down the entire cost price and has his ranch clear, he is not yet safely established, for he needs in addition a considerable working capital in order to buy the necessary equipment and keep it in repair. This accounts for the fact that in some cases where ranches were entirely free of debt owners have been obliged, by reason of lack of working capital and a series of unfavorable seasons, to mortgage their ranches and eventually lose them.

Table V shows the per cent of interest realized on investment per box at various prices for fruit. Figured on a basis of average annual yield per acre, the apple-land investment per box is $2.73 for Mesa, $2.13 for Delta, and $1.62 for Montrose, or $2.30 per box for all orchards. The annual cost of production per box minus the interest charge on apple land for these counties respectively is $0.716, $0.624, and $0.637, or for all counties it is practically $0.66 per box. It is seen that with fruit at $0.50 a box the grower on the farms studied in the Grand Valley loses 7.9 per cent on his investment, or for all counties he loses 6.95 per cent. If fruit brings $0.90 a box, he makes 6.73 per cent in the Grand Valley, or 10.44 per cent for all counties. When all counties are considered he must get $0.844 per box in order to make 8 per cent interest on his investment. When all grades of box apples are considered it is seldom of late years that a grower receives a price of $1 per box f. o. b. on his apples, and the average is usually considerably less.

**Table** V.—*Per cent of interest the average grower realizes on his investment in bearing apple orchard (125 ranches, western Colorado).*

| Price per box, f. o. b. | Per cent of interest realized on investment. | | | |
|---|---|---|---|---|
| | Mesa. | Delta. | Mont-rose. | All counties. |
| $0.50 | − 7.92 | − 5.83 | − 8.51 | − 6.95 |
| .60 | − 4.26 | − 1.14 | − 2.33 | − 2.60 |
| .75 | + 1.23 | + 5.91 | + 6.93 | + 3.92 |
| .90 | + 6.73 | +12.95 | +16.19 | +10.44 |
| 1.00 | +10.39 | +17.64 | +22.36 | +14.78 |
| 1.25 | +19.55 | +29.38 | +37.79 | +25.66 |

## LABOR.

The growers of Grand Valley depend principally on day labor for help. In Delta and Montrose Counties considerable month labor is hired. The average price paid for month labor varies from $30 to $60 per month, depending on the privileges the laborer receives. In all three counties, up to 1915, the average day-labor rate for orchard work, except pruning, was 25 cents per hour. Pruning was 35 cents per hour. Work done by the farmer or any of his family is counted at the current rate. Labor conditions are as good as can be expected. There is seldom a great scarcity of help.

Horse labor is charged at a nominal rate of 15 cents per hour. On many of these ranches two horses are kept in comparative idleness throughout the year, except during harvesting, spraying, hauling brush, and spring cultivating. Although hay is cheap and little grain is fed, it costs fully 15 cents per hour for productive horse labor.

The labor on apples is unevenly distributed. It reaches its highest point at harvesting time and during thinning in the latter part of June, when there is also a certain amount of cultivating and spraying to be done. It is high in March, as much of the pruning and removing of brush from the orchard is done during that month. If the labor curve for the few men who smudge were shown it would be high in April and May, but considering the general practice the curve is low in April. The accompanying labor chart (fig. 3) shows the approximate annual distribution of labor on an acre of bearing orchard (125 records).

## THE ORCHARDS.

### LOCATION.

The fruit district known as the Grand Valley is situated in Mesa County, of which Grand Junction is the county seat. Locally the Grand Valley district is divided into four different districts, known as the Palisade district, the Clifton district, the Grand Junction district, and the Fruita district. These districts all merge into each other, but have more or less distinctive features. The principal fruiting section of the Grand Valley is about 30 miles in length. The oldest, largest, and most famous district is that about Grand Junction. Here nearly all peach orchards have been or are being eradicated. In the Clifton district are found about as many pears as apples, and there is no doubt that the soils about Clifton are well suited to the growing of pears. The Palisade district is primarily devoted to peaches. In the Fruita district, which has now lost much of its commercial importance, apples come first, with a few pears and practically no peaches.

In the Grand Valley the fruit is not located on mesa lands, except on Orchard Mesa, across the river from Grand Junction. Most of the fruit is in the main river valley, but lies back some distance from the river, owing to the lands first settled next to the river having gone to seep.

In Delta County the fruit occupies a much more scattered area. The fruit in this county is located from Delta to Paonia in the valley of the Gunnison and the North Fork of the Gunnison. The bearing apple orchards are found principally about the towns of Austin, Cedaredge, Hotchkiss, and Paonia. With few exceptions these orchards are located on mesa lands.

In Montrose County the orchards are practically all on the mesa lands, the most important of which is Spring Creek Mesa. Ash and California Mesa also have a small amount of fruit.

### SIZE OF ORCHARDS.

The size of the bearing orchards found on farms varies greatly, the extremes of the records in Mesa being 2 and 27 acres, the majority being between 5 and 10 acres. In Delta the variation was from 3 to 45 acres, the majority being between 6 and 15 acres, and in Montrose from 5 to 40 acres, and an average of between 10 and 15 acres. Of young apple trees there was an average acreage per farm of 3.5, 4.94, and 3.56 acres, respectively, in Mesa, Delta, and Montrose Counties.

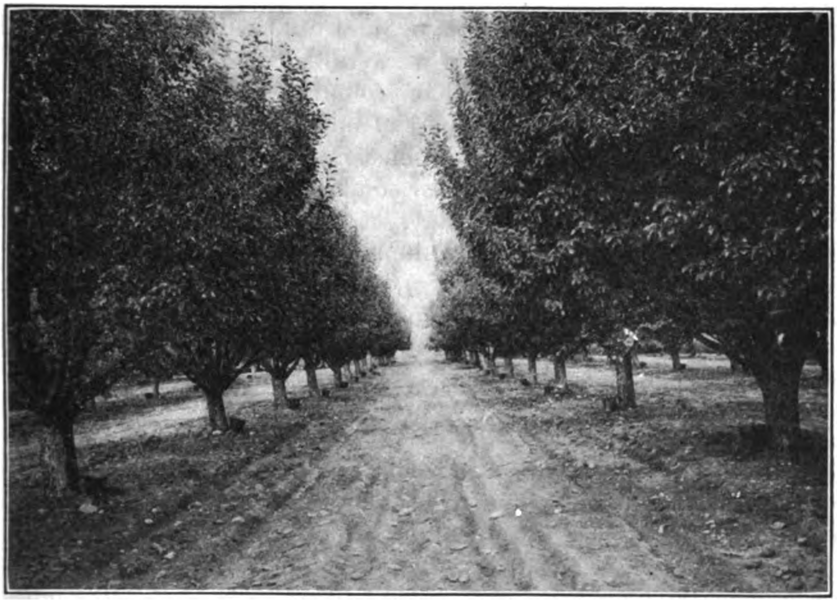


FIG. 4.—A 15-year-old Ben Davis orchard in full bearing located on Spring Creek Mesa, Montrose County. Note the vigorous growth of these trees which have been heavily manured. This orchard has always been clean cultivated.

### AGE OF ORCHARDS.

The orchards from which records were taken were fairly uniform in age, averaging 17½ years in Mesa, 17 in Delta, and 16½ in Montrose. Practically all were between the ages of 12 and 20 years. There are, however, many orchards older than 20 years, but these are not the commercial orchards and are usually of small acreage. At the time of this investigation there were practically none over 30 years of age.

### VARIETIES.

A great number of varieties of apples are found in this region. In the old orchards there are varieties of every season and often not enough of any one to market in commercial quantities. In the orchards over 20 years of age one often finds over 10 or 12 varieties, and one grower in Delta claimed 161 distinct varieties. This, of course, is an exception. Usually these early orchards were set out for family use; hence the great number of varieties of different seasons of ripening.

For the most part the apples which were considered of commercial importance 20 years ago, such as Baldwin, Ralls, Willowtwig, Smith Cider, Lawver, Missouri, Ben Davis, and others, are not considered as such to-day. Ben Davis, however, still is one of the leading commercial varieties, though it is seldom found in the young orchards.

The variety of greatest commercial importance here is the Jonathan. In the bearing orchards studied this is followed by Ben Davis, but in the young orchards and those coming into bearing it is followed by Winesap, Gano, and Rome Beauty, each of about equal importance. Other varieties of considerable commercial importance are Missouri, Arkansas (Mammoth Black Twig), Arkansas Black, White Pearmain, and Grimes. The younger plantings are made up of varieties now regarded as commercial, such as Jonathan, Winesap, Gano, Rome Beauty, Grimes, Wealthy, and a few Delicious and Banana.

### NUMBER OF TREES PER ACRE.

There is an average of 70 trees per acre in the bearing orchards of Mesa County, 78 trees per acre in Delta County, and 71 trees per acre in Montrose. The trees per acre in Mesa range from 42 to 125, in Delta from 40 to 133, and in Montrose from 39 to 100. This wide variation is due to the method used in setting. On the farms studied in Mesa County there were 8 orchards set 20 by 20 and 7 set 30 by 30 on the square. Several used the diagonal or quincunx system of setting. In Delta and Montrose there was fully as much variation, some old orchards on the lowlands being set as close as 15 by 15. However, the method more generally in use now is the diagonal plan. Most of the younger orchards are now set 28 by 28 or 30 by 30 on the diagonal.

### ORCHARD MANAGEMENT PRACTICE.

Under orchard practice is included manuring, pruning, hauling and burning brush, plowing and all cultivating operations, irrigating, thinning, putting on and tending codling-moth bands, spraying, scraping trees, harvesting labor, including all labor used in handling the crop from the time it is picked from the trees until delivered at the warehouse or station, and certain minor items classed as "miscellaneous."

### MANURING.

In the Grand Valley the application of manure on orchards is not a general practice. The ranchers of this vicinity keep but a small amount of stock and thus little manure is produced on the farm. Sixteen of the 49 growers visited in Mesa County, or 32.6 per cent, make a practice of manuring all or part of their orchard each year. The labor cost per acre is $2.04 and the material cost $3.57. In Delta County a large proportion of the growers apply manure, owing to the fact that Delta is a more general farming county than Mesa, and the average number of animals units per farm is larger. Thirty-one (50.8 per cent) of the 61 men visited in this county apply manure. Here the cost of labor per acre is $2.62; of material, $6.38. In Montrose County the type of farming is still more general, and more stock is kept; hence a still greater percentage of growers apply manure. Ten of the 15 men visited in Montrose, or 66 per cent, practice manuring, at a cost of $4.28 per acre for labor and $6.35 for material (see fig. 4).

For the three counties there is an average annual acre charge of 10.62 man-hours and 20.20 horse-hours, and an average application of 7.71 tons per acre, for the 57 men (45.6 per cent) who practice manuring.

It should be explained in this connection that the manure applied per man-hour appears low because of the fact that there is but little manure, which usually is drawn out in very small loads and applied only where most needed. Thus, these figures would not be applicable to conditions in which plenty of manure is available. (See Table VI.)

Commercial fertilizers are not used in this region.

TABLE VI.—*Manuring practice and costs for farms studied.*

| Item. | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Farms applying manure: | | | | |
| Number | 16 | 31 | 10 | 57 |
| Per cent of all farms | 32.6 | 50.8 | 66.7 | 45.6 |
| Averages per acre for farms applying manure: | | | | |
| Man-hours | 11.36 | 9.9 | 11.66 | 10.62 |
| Horse-hours | 22.72 | 17.9 | 23.32 | 20.20 |
| Tons of manure | 7.28 | 8.37 | 6.35 | 7.71 |
| Cost of labor | $6.25 | $5.16 | $6.41 | $5.69 |
| Cost of material | $10 92 | $12.56 | $9.53 | $11.56 |
| Averages per acre, distributed over all farms studied: | | | | |
| Man-hours | 3.71 | 6.03 | 7.77 | 4.84 |
| Horse-hours | 7.42 | 9.10 | 15.55 | 9.21 |
| Tons of manure | 2.38 | 4.25 | 4.23 | 3.51 |
| Cost of labor | $2.04 | $2.62 | $4.28 | $2.59 |
| Cost of material | $3.57 | $6.38 | $6.35 | $5.27 |
| Total cost | $5.61 | $9.00 | $10.62 | $7.86 |

## PRUNING.

Pruning is an operation practiced every year by all growers. It is done during the winter or dormant season. Hired help is usually paid more than the regular rate for pruning, as this operation requires skill. If a grower prunes for another he usually values his time at 35 cents per hour, so in pruning this rate is used.

In Mesa County the 49 growers prune an average of 11.18 trees in 10 hours, which, with an average of 70 trees per acre in the county, amounts to 62.61 man-hours per acre, which, figured at 35 cents per hour, makes an average annual acre charge of $21.91. The trees in Mesa average 17 years in age. (See Table VII.)

In Delta County less time is given to pruning than in Mesa. The 61 growers in this county prune an average of 16.34 trees in 10 hours, which makes the annual acre charge $16.71. The trees average 17½ years in age.

In Montrose County the time required is slightly greater than in Delta County, one man pruning 14.61 trees in 10 hours, at a cost of $17.01 per acre. The trees average 16½ years in age.

If the pruning costs of the 125 records are combined, it is found that with an average of 74 trees per acre one man will prune 14.11 trees in 10 hours, or spend 53.67 hours per acre, or a cost of $18.78 per acre on 17-year-old trees, making an annual charge of $0.254 per tree for pruning.

The orchards surveyed in these three counties were of such uniform age that the difference between individual records depends more on the individual growers' system of pruning than any difference in age of orchards. Varieties and methods of pruning influence the cost. For instance, the cost of pruning Winesap or Arkansas Black is more than that of pruning Ben Davis or Gano.

The systems of pruning are many, but the general method is to prune for an open head and a low tree, with plenty of fruiting surface. Much of the pruning is done by means of pruning shears, since on account of the regular pruning which the orchard receives there are not many large limbs to cut.

TABLE VII.—*Labor costs for pruning (125 ranches, western Colorado).*

| Item. | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Number of estimates | 49 | 61 | 15 | 125 |
| Number of trees per acre | 70 | 78 | 71 | 74 |
| Age of trees | 17 | 17½ | 16½ | 17 |
| Number of trees pruned in 10 hours | 11.18 | 16.34 | 14.61 | 14.11 |
| Man-hours per acre | 62.61 | 47.73 | 48.59 | 53.67 |
| Cost per acre | $21.91 | $16.71 | $17.01 | $18.78 |

### HAULING AND BURNING BRUSH.

The cost of picking up, hauling, and burning or getting rid of the brush from the orchard varies greatly, according to the facilities for handling it. In the three counties the usual method is to pick, haul, and burn at the same time. In Mesa County 22 growers use a 1-man 2-horse crew, 22 use a 2-man 2-horse crew, and 5 use a combination of crews and methods. It is found that here the 1-man 2-horse crew, with a total cost of $4.11 per acre, is slightly more efficient than the 2-man 2-horse crew, which costs $4.82 per acre. There were not enough records of other combinations to justify conclusions. In Delta County 19 men used a 1–2 crew, 37 a 2–2 crew, and 5 other methods. Here the 2–2 crew was not nearly so efficient as the 1–2 crew, the former costing $4.06 per acre, as against $2.96 for the latter. In Montrose County, with four 1–2 crews and ten 2–2 crews, there is a difference in cost of $0.30 per acre in favor of the 1–2 crew on the farms studied.

The total costs for the three counties, regardless of the crews used as well as the time and cost of the three counties combined, are given in Table VIII.

Table VIII.—*Time and cost per acre for disposing of brush (125 ranches, western Colorado).*

| Item. | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Number of records | 49 | 61 | 15 | 125 |
| Number man-hours | 9.75 | 8.46 | 6.43 | 8.72 |
| Number of horse-hours | 12.84 | 9.90 | 7.78 | 10.64 |
| Cost | $4.36 | $3.60 | $2.77 | $3.78 |

### CULTIVATION.

Under the general heading of cultivation are grouped all the various tillage operations. These are plowing, disking, harrowing with both spike and spring tooth, floating, cultivating, and marking or creasing out the furrows for irrigation. The normal time has been obtained for these different operations and the cost per acre for each operation figured, but in the final charge the same system of distributing the cost is used as previously explained.

On account of the fact that clean cultivation is being abandoned in this region and the use of a mulch crop is coming into a more general practice, especially in Delta County, the final figures for cultivation are too low for clean-cultivated orchards. At the time of this investigation an attempt was made to separate the cultivating costs on the clean cultivation records from the costs on mulch crops or sod orchards, but on account of the fact that the change in practice from clean cultivation to the use of a mulch crop or sod, is now in a transitory stage and has not been in practice long enough to affect yields, it was difficult in many cases to determine which orchards should be regarded as clean cultivated and which as mulch crop. Many use a thick growth of weeds for a mulch crop, and in such cases there is often considerable cultivation before the weeds are allowed to grow. (See Table IX.)

TABLE IX.—*Ranches classified by soil management (125 ranches, western Colorado).*

| Soil management. | Number of ranches. | | | |
|---|---|---|---|---|
| | Mesa. | Delta. | Montrose. | All counties. |
| Clean cultivation | 32 | 13 | 7 | 52 |
| Clover | 4 | 23 | 4 | 31 |
| Weeds | 5 | 11 | 0 | 16 |
| Alfalfa | 7 | 9 | 4 | 20 |
| Vetch | 1 | | | 1 |
| Alfalfa and clover | | 5 | | 5 |

Plowing is sometimes done in early spring, but most men plow in the late fall. A few, particularly in Delta County, plow the mulch crop under during the summer. By plowing in the fall, the ground is given the full benefit of the moisture of the snow which falls during the winter.

Some ranchers do not plow every year. In Mesa County, for example, 25 men plow every year, 12 plow every 2 years, 5 plow every 3 years, and 1 plows every 4 years, making a total of 43, or nearly 88 per cent, who plow. However, the percentage is reduced to 67 if figured as an annual charge against the total number of records. For Montrose this percentage is the same as for Mesa; for Delta it is 48.

The plowing cost per acre for all counties is $3.83, one man and team plowing 1.44 acres per day. There is never more than one plowing during the season, but the cultivating tools are used after each irrigation to a certain extent.

In Table X the 125 ranches are classified according to practices in cultivation.

TABLE X.—*Cultivation practices (125 ranches, western Colorado).*

| | Mesa. | | | Delta. | | | Montrose. | | | All counties. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number records. | Times over. | Per cent records. | Number records. | Times over. | Per cent records. | Number records. | Times over. | Per cent records. | Number records. | Times over. | Per cent records. |
| Disk | 19 | 1.8 | 39 | 36 | 2 | 59 | 8 | 1.9 | 53 | 63 | 1.9 | 50.4 |
| Spring-tooth | 10 | 2 | 20 | 23 | 1.5 | 38 | 6 | 2.3 | 40 | 39 | 1.8 | 31.2 |
| Spike-tooth | 25 | 1.8 | 51 | 14 | 1.9 | 23 | 5 | 1.8 | 33 | 44 | 1.8 | 35.2 |
| Cultivate | 18 | 1.6 | 37 | 7 | 2.1 | 12 | 1 | 2 | 7 | 26 | 1.8 | 20.8 |
| Float | 35 | 1.2 | 71 | 19 | 1.2 | 31 | 8 | 1.6 | 53 | 62 | 1.3 | 49.6 |
| Crease | 49 | 1 | 100 | 61 | 1 | 100 | 15 | 1 | 100 | 125 | 1 | 100 |
| Irrigation. | | | | | | | | | | | | |
| Disk | 1 | 2 | 2 | 11 | 1.9 | 18 | 5 | 2.4 | 33 | 17 | 2.1 | 13.6 |
| Spring-tooth | 3 | 1.7 | 6 | 11 | 1.6 | 18 | 3 | 1.3 | 20 | 17 | 1.6 | 13.6 |
| Spike-tooth | 8 | 1.3 | 16 | 3 | 1 | 5 | 1 | 2 | 7 | 12 | 1.3 | 9.6 |
| Cultivate | 27 | 1.9 | 55 | 9 | 1.8 | 15 | 1 | 2 | 7 | 37 | 1.9 | 29.6 |
| Float | 6 | 1 | 12 | ... | ... | ... | 2 | 2 | 13 | 8 | 1.3 | 6.4 |
| Crease | 38 | 1 | 77 | 33 | 1 | 52 | 7 | 1 | 47 | 78 | 1 | 62.4 |
| Irrigation. | | | | | | | | | | | | |
| Disk | 2 | 2 | 4 | 9 | 1.9 | 15 | 4 | 1.8 | 27 | 15 | 1.9 | 12 |
| Spring-tooth | 2 | 2 | 4 | 7 | 1.4 | 12 | 3 | 1 | 20 | 12 | 1.4 | 9.6 |
| Spike-tooth | 5 | 1.2 | 10 | 3 | 1.3 | 5 | 2 | 3 | 13 | 10 | 1.6 | 8 |
| Cultivate | 24 | 1.4 | 49 | 7 | 1.9 | 12 | ... | ... | ... | 31 | 1.5 | 24.8 |
| Float | 3 | 1 | 6 | 2 | 1 | 3 | 3 | 1.7 | 20 | 8 | 1.3 | 6.4 |
| Crease | 28 | 1 | 57 | 22 | 1 | 35 | 7 | 1 | 47 | 57 | 1 | 45.6 |
| Irrigation. | | | | | | | | | | | | |
| Disk | ... | ... | ... | 2 | 1.5 | 3 | 3 | 2.3 | 20 | 5 | 2 | 4 |
| Spring-tooth | 3 | 1.7 | 6 | 3 | 1.7 | 5 | 2 | 1 | 13 | 8 | 1.5 | 6.4 |
| Spike-tooth | 2 | 1 | 4 | 2 | 1.5 | 3 | 2 | 3 | 13 | 6 | 1.8 | 4.8 |
| Cultivate | 11 | 1.7 | 22 | 3 | 1.3 | 5 | ... | ... | ... | 14 | 1.6 | 11.2 |
| Float | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 1.50 | 13 | 4 | 1.3 | 3.2 |
| Crease | 13 | 1 | 26 | 8 | 1 | 13 | 5 | 1 | 33 | 26 | 1 | 20.8 |
| Irrigation. | | | | | | | | | | | | |
| Disk | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Spring-tooth | ... | ... | ... | 1 | 1 | 2 | ... | ... | ... | 1 | 1 | 0.8 |
| Spike-tooth | 1 | 1 | 2 | ... | ... | ... | ... | ... | ... | 1 | 1 | 0.8 |
| Cultivate | 1 | 2 | 2 | 1 | 2 | 2 | ... | ... | ... | 2 | 2 | 1.6 |
| Float | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Crease | 3 | 1 | 6 | 2 | 1 | 3 | ... | ... | ... | 5 | 1 | 4 |
| Irrigation. | | | | | | | | | | | | |

Creasing is a universal practice before the first irrigation, and when there are any cultivations between irrigations the operation is repeated. The next most prevalent practice in cultivation is the use of the disk, followed by the float, spike-tooth, spring-tooth, and lastly the cultivator, in the order named. In Table X, however, the tools are named in the order in which they are used.

The disk, usually a 4-foot or 6-foot extension disk, is used quite generally on the alfalfa orchards in early spring and perhaps even after one or two irrigations. The spring-tooth is used to some extent on the sod orchards in early spring, but is largely confined to clean cultivation. Spike-tooth, float, and the cultivator are almost entirely confined to the clean-cultivation orchards. It should be explained that in creasing there are two very distinct tools used, viz, a cultivator which usually makes two or three furrows at a time and the shovel plow, which makes but one. The cultivator is the tool most commonly used, except in sod orchards, where there are many roots to contend with, where a shovel plow is usually used. In clean cultivation one horse ordinarily can handle a shovel plow, but under the conditions which make the use of this tool desirable here, two horses are commonly used. Indeed, the two-horse team is most commonly used in all operations. More than two horses are rarely used and only a few men, owners of small orchards, use one horse.

In order to show the normals of these different operations as arrived at by the estimates of all growers who practiced them, Table XI has been prepared merely to show normal time required. It should be understood in this connection that these normal times and costs do not refer to the actual costs per record, but refer only to the actual average cost of one operation on 1 acre with a given cultivating tool. In arriving at actual costs chargeable, take Mesa County, where 39 per cent of the growers of the county practice disking before the first irrigation, and they go over the ground an average of 1.8 times; then to find the cost per record, using an acre as the unit for the county, take the normal time for that given operation, multiply it by the average number of times over, and then by the per cent of growers in the county practicing the operations, as 2.28 (normal man-hours per acre) × 1.8 (number of operations) × 0.39 (per cent of men who practice it) – number of man-hours chargeable.

Number of man-hours × man-hour rate = cost of man-labor.
Number of horse-hours × horse-hour rate = cost of horse-labor.

Normals in this table are given only for one-man two-horse crews, as the few other combinations found are not numerous enough to give a normal. Cultivating times vary somewhat, according to conditions of the soil and the season, so that in some instances more than one estimate covering cultivations between different irrigations have been used in figuring the normal. This accounts for the number of estimates being larger in some cases than the number of records.

TABLE XI.—*Normal time in cultivation (1-man, 2-horse).*

| Operation. | Mesa. | | | | Delta. | | | |
|---|---|---|---|---|---|---|---|---|
| | Number estimates. | Man-hours per acre. | Acres per day. | Cost per acre. | Number estimates. | Man-hours per acre. | Acres per day. | Cost per acre. |
| Plow | 43 | 6.86 | 1.46 | $3.77 | 40 | 7.25 | 1.38 | $3.99 |
| Disk | 22 | 2.28 | 4.39 | 1.25 | 57 | 1.88 | 5.32 | 1.03 |
| Spring-tooth | 18 | 1.37 | 7.30 | .75 | 45 | 1.63 | 6.13 | .90 |
| Spike-tooth | 40 | 1.18 | 8.47 | .65 | 22 | 1.28 | 7.81 | .70 |
| Cultivate | 70 | 1.70 | 5.88 | .94 | 27 | 1.69 | 5.92 | .93 |
| Crease | 105 | 1.12 | 8.93 | .62 | 109 | 1.17 | 8.54 | .64 |
| Shovel plow (1 man, 2-horse) | 16 | 2.06 | 4.85 | 1.13 | 10 | 1.92 | 5.21 | 1.06 |
| Float | 43 | 1.33 | 7.50 | .73 | 21 | 1.44 | 6.94 | .79 |

TABLE XI.—*Normal time in cultivation (1-man, 2-horse)*—Continued.

| Operation. | Montrose. | | | | 3 counties. | | | |
|---|---|---|---|---|---|---|---|---|
| | Number estimates. | Man-hours per acre. | Acres per day. | Cost per acre. | Number estimates. | Man-hours per acre. | Acres per day. | Cost per acre. |
| Plow | 10 | 6.34 | 1.58 | $3.49 | 93 | 6.97 | 1.44 | $3.84 |
| Disk | 20 | 1.41 | 7.59 | .78 | 99 | 1.87 | 5.35 | 1.03 |
| Spring-tooth | 14 | 1.27 | 7.87 | .70 | 77 | 1.50 | 6.67 | .83 |
| Spike-tooth | 10 | .93 | 10.75 | .51 | 72 | 1.18 | 8.47 | .65 |
| Cultivate | 2 | 1.33 | 7.52 | .73 | 99 | 1.69 | 5.92 | .93 |
| Crease | 34 | .85 | 11.76 | .47 | 248 | 1.10 | 10.00 | .61 |
| Shovel plow (1 man, 2-horse) | | | | | 26 | 2.01 | 4.98 | 1.11 |
| Float | 15 | .93 | 10.80 | .51 | 79 | 1.28 | 7.81 | .70 |

After figuring out the costs of all cultivation, including plowing, and distributing that cost over the total number of records, there is indicated for Mesa County an average cost of $9.98 per acre as compared with $7.74 for Delta, where less clean cultivation is practiced, and $8.39 for Montrose, where more clean cultivation is practiced than in Delta but less than in Mesa. The average for the three counties is $8.70. (See Table XII.)

TABLE XII.—*Cost of cultivation on farms studied.*

| Item. | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Man-hours per acre | 18.55 | 14.08 | 15.25 | 15.97 |
| Horse-hours per acre | 35.63 | 28.14 | 30.50 | 31.36 |
| Cost per acre | $9.98 | $7.74 | $8.39 | $8.70 |
| Cost per box | $0.035 | $0.027 | $0.030 | $0.030 |

## MULCH CROPS.

The practice of using a mulch crop has a direct bearing on the extent, kind, and cost of cultivation. The term mulch cropping, in this connection, refers to the practice of growing alfalfa, clover, or any other crop in the orchard to be taken off as hay or turned under as fertilizer. Strictly speaking, in many of these cases these crops might be referred to as shade crops instead of mulch crops. The growers call them cover crops. Up to three or four years ago clean cultivation was the universal practice, and the method was more intensive than that now in vogue (see fig. 5). However, the practice of using a mulch crop has been gaining in favor very rapidly, so that in a few years it is likely that clean cultivation as a regular practice will be generally discontinued. Considerable cultivation is necessary, of course, even with a cover crop, for alfalfa is usually disked annually and clover is turned under every two or three years and the orchard cultivated for a year before it is sown again. When weeds or sweet clover are used as a mulch crop the orchard is clean cultivated during the first part of the season and they are allowed to grow after the first or second irrigation.

As has been explained, it was impossible to separate the figures for the different kinds of soil management and have enough records of any one kind to give the figures conclusive meaning, so that all work is averaged over the total number of records.

As yet comparatively little income has been derived from hay taken from these orchards. The mulch crops have been so recently established that most growers still leave the crop on the ground after mowing. However, since the recent decline in the price of apples, growers are coming more and more to realize the necessity of getting something more than apples from their land. Thus, in the year 1915 many men mowed their orchards and saved the hay for feed. The few men who cut orchard hay harvested 1½ to 5 tons per acre of alfalfa. Clover, less frequently taken off, averages much less per acre. The cost of harvesting this hay is about $2.50 per ton, and the local price $4 to $8, so that there is often a considerable hay credit to an orchard. In these figures, however, owing to the mulch-crop system not having been firmly established at the time the records were taken, no consideration is given to hay in the cost tables. In general, however, it may be said that a system of mulch or cover crops cropping is becoming very popular in western Colorado and intensive clean cultivation in the bearing orchards has but few advocates (see figs. 6 and 7).

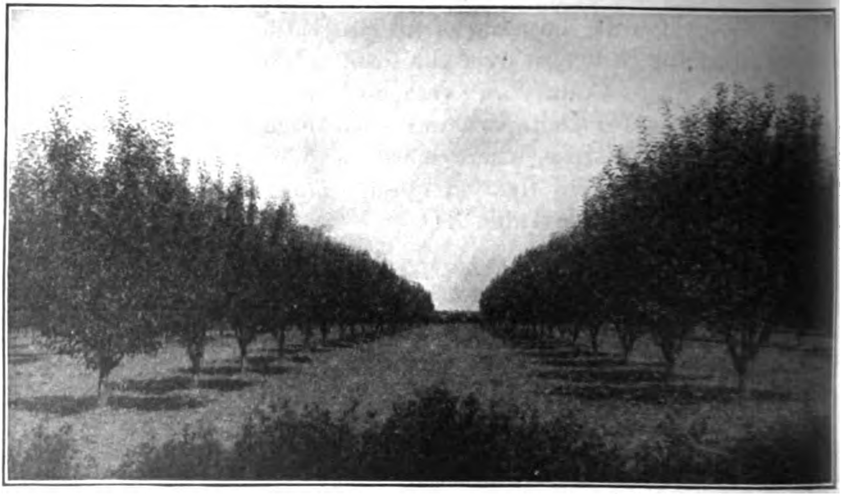


FIG. 5.—A 7-year-old orchard in the Grand Valley under the intensive clean cultural system of soil management. Note how close the trees are set in the row.

## IRRIGATION.

The cost of irrigation depends on method, quantity of water available, rate of flow, topography, condition of the soil, length of furrows, width of furrows, and the time of year. The usual method of irrigation is by open ditches. The water is carried from the main ditch to the ranches in smaller open ditches, known as laterals. From

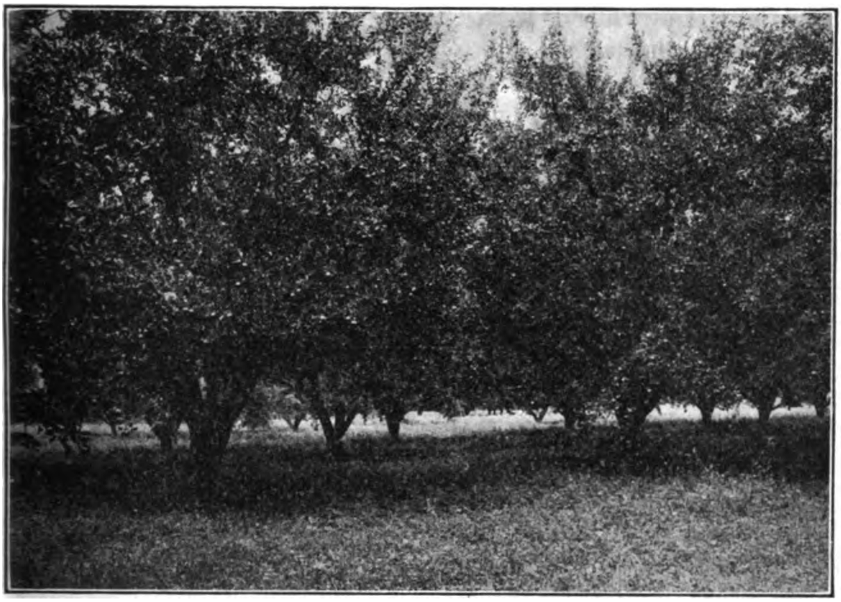


FIG. 6.—A 22 year-old Grimes orchard located on sandy soil in the river bottom section near Paonia. The clover in this orchard acts as a shade crop and is sometimes turned under but never taken off.

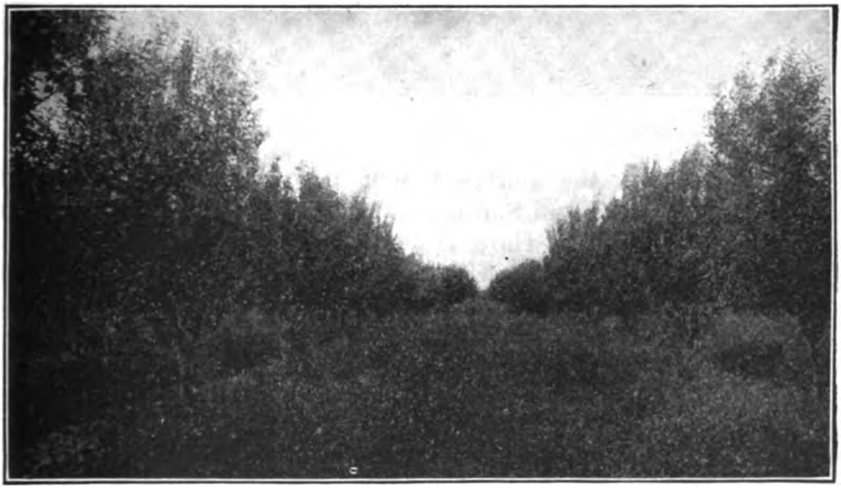


FIG. 7.—A 7-year-old orchard in the Grand Valley showing the clover shade crop between rows.

them it is delivered to the orchards by means of open ditches, wooden flumes, or pipes. Piping is the quickest and most convenient method, but this system, because of the great initial expense, is not generally used.

In the Grand Valley (Mesa County) the majority of the growers water their orchards from the Grand Valley Canal at a cost of 88 cents per acre per annum. Water from the Price ditch costs per year about $4 per acre. The growers interviewed on orchard mesa have to pay much more per acre for their water, which is pumped. Along the Grand River and canal are a number of water wheels that raise water for small tracts. (See fig. 8.) This river is the source of all water used for irrigation on the farms studied in Mesa County.

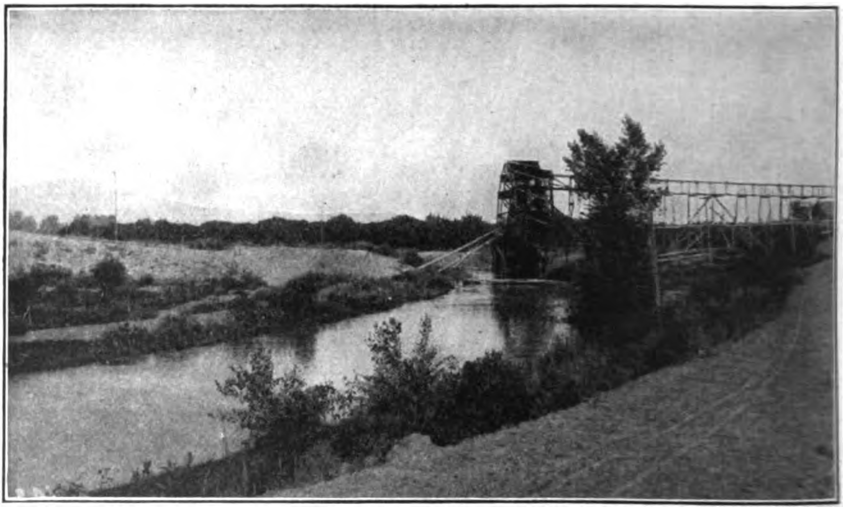


FIG. 8.—Method of raising water to irrigate lands above the Grand Valley canal near Grand Junction.

In Delta County the sources of irrigation are the Gunnison and Uncompahgre Rivers and Surface and Forked Tongue Creeks. The water for the Paonia and Hotchkiss district is largely from the North Fork of the Gunnison River, while the region about Austin is watered by Surface Creek. The water sells by shares at an annual assessment per share, so that there is no fixed acre charge for water rent.

In Montrose County the water for Spring Creek Mesa is taken from the Government project canal, which was completed in 1910 and absorbed the canals of the old Uncompahgre Ditch & Land Co. Generally speaking, there is no lack of water for irrigation purposes; indeed, water frequently has been applied too freely, as the orchardists themselves testify. In many places, especially in the Grand Valley, the ground has been so thoroughly saturated that alkali has been brought to the surface and killed hundreds of acres of formerly productive orchards.

TABLE XIII.—*Number of irrigations (125 ranches, western Colorado).*

| Irrigation. | Mesa (49 farms). | | | Delta (61 farms). | | | Montrose (15 farms). | | | All counties (125 farms). | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per cent reporting. | Average time. | Time chargeable. | Per cent reporting. | Average time. | Time chargeable. | Per cent reporting. | Average time. | Time chargeable. | Number reporting. | Per cent reporting. | Average time. | Time chargeable. |
| | | *Hrs.* | *Hrs.* | | *Hrs.* | *Hrs.* | | *Hrs.* | *Hrs.* | | | *Hrs.* | *Hrs.* |
| First | 100 | 2.78 | 2.78 | 100 | 3.49 | 3.49 | 100 | 3.64 | 3.64 | 125 | 100 | 3.23 | 3.23 |
| Second | 100 | 2.71 | 2.71 | 100 | 3.41 | 3.41 | 100 | 3.32 | 3.32 | 125 | 100 | 3.12 | 3.12 |
| Third | 95.9 | 2.67 | 2.56 | 96.7 | 3.36 | 3.25 | 100 | 3.32 | 3.32 | 121 | 96.8 | 3.09 | 2.99 |
| Fourth | 87.7 | 2.53 | 2.22 | 85.2 | 3.39 | 2.89 | 66.7 | 2.32 | 1.54 | 105 | 84 | 2.94 | 2.47 |
| Fifth | 51 | 1.95 | .99 | 54.1 | 2.98 | 1.61 | 33.3 | 2.02 | .68 | 63 | 50.4 | 2.50 | 1.26 |
| Sixth | 18.3 | 1.43 | .26 | 21.3 | 3.61 | .77 | 20 | 2.08 | .42 | 25 | 20 | 2.64 | .53 |
| Seventh | 6.1 | 1.01 | .06 | 8.2 | 2.79 | .23 | 6.6 | 1.20 | .08 | 9 | 7.2 | 2.02 | .15 |

Table XIII shows that the greatest time is required for the first irrigation, with a slightly shorter time for the second and third, and that thenceforward the time decreases with each irrigation. This is due to the fact that the fifth, sixth, and seventh irrigations are performed only by those men who water their orchards lightly and often, while the first three irrigations include all who water heavily and but three times during the season. Thus it will be seen that the average time for irrigation falls off as the number of irrigations per season increase.

The number and the length of furrows naturally influence the time. Where furrows are long it takes considerable time for the water to reach the far end; furthermore, the soil tends to become oversaturated at the head of the furrow. The number of furrows varies from 3 to 8, with an average of 5, about an equal number using 4, 5, and 6 furrows. The number of furrows, of course, depends on width of row, tool used, kind of soil, and how long the water is to be left on. The farther the furrows are apart the longer the water is left on. This time varies from 12 to 72 hours, but is usually between 36 and 48 hours. The number of sets necessary depends on the quantity of water used. The usual allowance in the Grand Valley is one-half inch per acre. In the other counties this figure varies.

TABLE XIV.—*Cost summary for all irrigations (125 ranches, western Colorado).*

| Per acre. | Mesa. | Delta. | Montrose. | Three counties. |
|---|---|---|---|---|
| Man-hours | 11.59 | 15.66 | 12.99 | 13.74 |
| Cost | $2.90 | $3.91 | $3.25 | $3.44 |

A comparison of time required throughout the region for irrigating in sod orchards and in orchards under clean cultivation shows that under clean cultivation the time averages about one-half hour longer per acre than on sod. This slight difference may be due to the fact that, in general, less care is taken in irrigating orchards in mulch crop, although to keep the mulch crop from clogging the furrows often entails extra work.

In Table XIV is given a cost summary for all irrigations.

### THINNING.

Thinning the fruit from the trees is a practice followed by the majority of growers. This operation is usually done in June or July, most growers thinning during the latter part of June. Thinning increases the size and color of the remaining fruit, and if practiced systematically eliminates in large measure the cull or poor fruit, thus saving harvest labor. This operation is done by hand, either by picking the apples or clipping them off with a thinning shears. The low-headed trees are most frequently thinned. It is not customary to thin branches which can not be reached from a stepladder. Apples are left from 3 to 6 inches apart. Some growers thin the clusters so that no two apples are borne on the same fruit spur.

Condition of crop and variety of apple are the most important factors influencing thinning. Some varieties, like Winesap, require so much more thinning than others, such as the Arkansas Black, that a general average of time required per acre for thinning is of little practical significance in itself. Estimates were obtained from each grower as to the number of trees a man would thin per 10-hour day, and as to the percentage of his trees thinned. These estimates were checked up with his estimate of the average time spent thinning his orchard per year. The averages derived from these estimates are shown in Table XV.

TABLE XV.—*Thinning practices and costs (125 ranches, western Colorado).*

| County. | Number of records. | Number of records of thinning. | Per cent practicing thinning. | Number of trees per acre. | Average size of orchard (acres). | Trees thinned in 10 hours. | Per cent of trees thinned. | Distributed hours per acre. | Cost per acre. |
|---|---|---|---|---|---|---|---|---|---|
| Mesa | 49 | 41 | 83.7 | 70 | 8.22 | 10.89 | 45.3 | 24.36 | $6.09 |
| Delta | 61 | 45 | 73.8 | 78 | 12.19 | 16.45 | 44.1 | 15.42 | 3.86 |
| Montrose | 15 | 6 | 40.0 | 71 | 13.66 | 13.85 | 26.0 | 5.35 | 1.34 |
| All counties | 125 | 92 | 73.6 | 74 | 10.81 | 13.96 | 43.45 | 17.71 | 4.43 |

It will be seen from these figures that the more general the farm the less thinning is practiced. There is a decided drop in Montrose County, where orchards as compared to those of Mesa are not given a great deal of care. It is significant that the greatest proportion of cull apples is found in Montrose. It will also be seen that the larger the orchard the less time is spent thinning per acre, which goes to account for the fact that orchards of larger acreages on the farms studied seldom produce as large a percentage of extra fancy fruit as do those of smaller size.

### PROPPING.

So few growers of western Colorado practice propping that this operation need not be discussed here as a regular orchard operation. All propping time is included in miscellaneous labor.

### CODLING MOTH BANDS.

A practice more common in western Colorado than in any place else in the United States is that of banding the tree for codling moth. This is particularly true of Mesa County. These bands are made of old sacks or cloth of any description, but the most satisfactory band is burlap. A band is placed around the tree from 8 to 12 inches from the ground. This is done about the middle of June and the band may be taken off in the fall or left on the tree. A band will last for two years on the tree, and if taken in during the winter will last longer. These bands are "worked" every week, ten days, or two weeks, depending on the prevalence of moths and the importance the grower attaches to the practice. By working the bands is meant the practice of removing the bands at one end from the trees and killing the codling moth larva. The larvæ after coming from the apple seek a place to pupate and select the band as an ideal place. A few growers use for this purpose an old sack stuffed into the fork of the tree. This answers practically the same purpose as the band, although probably somewhat less effective.

The time required for working depends very largely on the number of worms found. Table XVI shows that the practice of banding is almost entirely confined to the Grand Valley, or Mesa County.

TABLE XVI.—*Time chargeable per acre for working codling moths.*

| Item. | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Number of records | 49 | 61 | 15 | 125 |
| Number using bands | 33 | 7 | .......... | 40 |
| Percentage using bands | 67.3 | 11.5 | .......... | 32 |
| Time chargeable per acre to put on bands (hour) | .77 | .11 | .......... | .35 |
| Number of times worked | 6.5 | 5.7 | .......... | 5.33 |
| Time chargeable per acre for working bands (hours) | 10.02 | 1.21 | .......... | 4.52 |
| Time to put on and workbands (hours) | 10.78 | 1.31 | .......... | 4.87 |
| Cost per acre | $2.70 | $0.33 | .......... | $1.22 |

### SPRAYING.

Spraying is one of the more important orchard practices of western Colorado, and one which, owing to a number of factors involved, varies greatly in the different counties.

The codling moth, because of the long season and dry climate, is very hard to control, especially in Mesa County, where conditions for its rapid development are very favorable. In Delta County the altitude is high enough and the climate moist enough to render the moth much less troublesome; indeed, in some of the higher orchards of this county it is almost unknown. For this reason there is much less spraying in Delta than in Mesa County. In Montrose County none of the growers visited sprayed over three times for the moth, the cost for that district falling even below that of Delta.

Besides the codling moth sprays it is now the general practice, enforced by law, to make a lime-sulphur spray for San Jose scale. At the time these records were taken, however (1914), only a few men sprayed for scale. Thus the cost of spraying for the region has been very materially increased since the figures here presented were obtained.

Sprays are also occasionally made with tobacco extract for aphis.

### CODLING MOTH SPRAYS.

In Mesa County the codling moth is impossible to control with present methods without several sprays. Considering all records, Mesa has an average of 5.28 sprays as against 3.16 for Delta County and 2.73 for Montrose County. The first lead-arsenate spray is called the calyx spray and is applied when about two-thirds of the petals have fallen or before the calyx closes. The next spray follows in about 10 days or 2 weeks. The dates of spraying always depend on the relative time of blooming, weather conditions, and the relative abundance of the moth. The grower uses his own judgment to a great degree as to when and how often these sprays should be applied, though he is guided to some extent by the inspection of the local association or county agent.

In each of the three counties spraying in the bearing orchards is done almost exclusively with a gasoline-power spray outfit. Thirty-seven of the 49 growers in Mesa own spray rigs, while 12 hire the spraying done. Of the 61 growers in Delta County 51 own and 10 hire. Of the 15 in Montrose all own except one, who hires.

The customary spray mixture for codling moth is arsenate of lead and water. Two kinds of lead arsenate are used, paste and dry. As over 90 per cent used the paste lead arsenate, this will be considered here as the general practice. In Mesa County the lead arsenate is mixed in the proportion of 8 pounds to 200 gallons of water. In Delta County the average is 8.02 pounds to 200 gallons, and in Montrose, 10.22 pounds to 200 gallons. The regular rate of spraying labor is $1 per hour for man, team, and rig. This figures the man labor at 25 cents per hour, the team and rig at 75 cents.

The usual spraying crew is 3 men and 2 horses, although many use 2 men and 2 horses. On the farms studied approximately 73.5 per cent use the 3–2 crew in Mesa County, 70.5 per cent in Delta, and 73.3 per cent in Montrose. In Mesa 20.4 per cent use the 2–2 crew, 19.6 per cent in Delta, and 6.7 per cent in Montrose. Of all other crews, which include 1–2 crews, 4–2 crews, etc., 2.04 per cent are found in Mesa, 9.93 per cent in Delta, and 20 per cent in Montrose. (See Table XVII.)

TABLE XVII.—*Spraying practices (125 ranches, western Colorado).*

| Spray. | Mesa. | | | | | Delta. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number. | Per cent. | Crew. | | | Number. | Per cent. | Crew. | | |
| | | | 3–2 | 2–2 | All others. | | | 3–2 | 2–2 | All others. |
| Using lime-sulphur spray | 20 | 41 | 15 | 4 | 1 | 4 | 7 | 4 | ...... | ...... |
| First lead arsenate spray | 49 | 100 | 36 | 10 | 3 | 61 | 100 | 43 | 12 | 6 |
| Second lead arsenate spray | 49 | 100 | 35 | 11 | 3 | 60 | 98 | 43 | 12 | 5 |
| Third lead arsenate spray | 49 | 100 | 36 | 10 | 3 | 45 | 74 | 33 | 10 | 2 |
| Fourth lead arsenate spray | 47 | 96 | 34 | 11 | 2 | 22 | 36 | 16 | 6 | ...... |
| Fifth lead arsenate spray | 42 | 86 | 30 | 10 | 2 | 5 | 8 | 3 | 2 | ...... |
| Sixth lead arsenate spray | 23 | 47 | 17 | 5 | 1 | ...... | ...... | ...... | ...... | ...... |

| Spray. | Montrose. | | | | | All counties. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number. | Per cent. | Crew. | | | Number. | Per cent. | Crew. | | |
| | | | 3–2 | 2–2 | All others. | | | 3–2 | 2–2 | All others. |
| Using lime-sulphur spray | 3 | 20 | 3 | ...... | ...... | 27 | 21.6 | 22 | 4 | 8 |
| First lead arsenite spray | 15 | 100 | 11 | 1 | 3 | 125 | 100 | 90 | 23 | 12 |
| Second lead arsenate spray | 15 | 100 | 9 | 3 | 3 | 124 | 99.2 | 87 | 26 | 11 |
| Third lead arsenate spray | 11 | 73 | 5 | 3 | 3 | 105 | 84.6 | 74 | 23 | 8 |
| Fourth lead arsenate spray | ...... | ...... | ...... | ...... | ...... | 69 | 55.2 | 50 | 17 | 2 |
| Fifth lead arsenate spray | ...... | ...... | ...... | ...... | ...... | 47 | 37.6 | 33 | 12 | 2 |
| Sixth lead arsenate spray | ...... | ...... | ...... | ...... | ...... | 23 | 18.4 | 17 | 5 | 1 |

Table XVII gives a general idea of the practice, while Tables XVIII and XIX give detailed data on the efficiency of the 3–2 crew as compared with the 2–2 crew, which is shown to be fully as efficient as the 3–2 crew. This is because ordinarily the third man of the 3–2 crew is a driver and does not handle an extra lead of hose. Thus there are usually only two leads of hose, whatever crew is used. Table XX summarizes the efficiency data for the 3–2 and 2–2 crews.

TABLE XVIII.—*Cost of operation for 3-men, 2-horse spraying crew.*

| Spray. | Number of records. | Normal time. | Acres per day. | Gallons per acre. | Gallons per tree. | Labor cost per acre. | Material cost per acre. | Total cost per acre. |
|---|---|---|---|---|---|---|---|---|
| Lime and sulphur spray | 22 | 6.8 | 4.4 | 358 | 5.1 | $2.38 | $8.23 | $10.61 |
| First lead arsenate spray | 90 | 7.81 | 3.8 | 519 | 7.1 | 2.73 | 2.15 | 4.88 |
| Second lead arsenate spray | 87 | 7.62 | 3.9 | 462 | 6.3 | 2.67 | 1.91 | 4.58 |
| Third lead arsenate spray | 74 | 7.62 | 3.9 | 480 | 6.6 | 2.67 | 1.98 | 4.65 |
| Fourth lead arsenate spray | 50 | 7.83 | 3.8 | 514 | 7.1 | 2.74 | 2.05 | 4.79 |
| Fifth lead arsenate spray | 33 | 7.81 | 3.8 | 542 | 7.6 | 2.73 | 2.17 | 4.90 |
| Sixth lead arsenate spray | 17 | 7.98 | 3.8 | 585 | 8.4 | 2.79 | 2.34 | 5.13 |
| All lead arsenate sprays | 351 | 7.73 | 3.8 | 501 | 6.8 | 2.71 | 2.07 | 4.78 |

TABLE XIX.—*Cost of operation for 2-men, 2-horse spraying crew.*

| Spray. | Number of records. | Normal time. | Acres per day. | Gallons per acre. | Gallons per tree. | Labor cost per acre. | Material cost per acre. | Total cost per acre. |
|---|---|---|---|---|---|---|---|---|
| Lime and sulphur spray | 4 | 6.14 | 3.3 | 324 | 4.6 | $2.46 | $7.45 | $9.91 |
| First lead arsenate spray | 23 | 6.21 | 3.2 | 550 | 7.4 | 2.48 | 2.27 | 4.75 |
| Second lead arsenate spray | 26 | 5.53 | 3.6 | 458 | 6.2 | 2.21 | 1.89 | 4.10 |
| Third lead arsenate spray | 23 | 5.60 | 3.6 | 446 | 6.0 | 2.24 | 1.84 | 4.08 |
| Fourth lead arsenate spray | 17 | 5.38 | 3.7 | 490 | 6.6 | 2.15 | 1.96 | 4.11 |
| Fifth lead arsenate spray | 12 | 5.27 | 3.8 | 531 | 7.2 | 2.11 | 2.12 | 4.23 |
| Sixth lead arsenate spray | 5 | 4.97 | 4.0 | 532 | 7.6 | 1.99 | 2.13 | 4.12 |
| All lead arsenate sprays | 106 | 5.61 | 3.6 | 491 | 6.6 | 2.24 | 2.03 | 4.27 |

TABLE XX.—*Summary of comparative efficiency data for spraying crews.*

| Crew. | Number of sprays studied. | Normal time man-hours. | Acres per day. | Gallons per acre. | Gallons per tree. | Cost per acre. | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Labor. | Material. | Total. |
| 3-2 | 351 | 7.73 | 3.8 | 501 | 6.8 | 2.71 | 2.07 | $4.78 |
| 2-2 | 106 | 5.61 | 3.6 | 491 | 6.6 | 2.24 | 2.03 | 4.27 |

## LIME-SULPHUR SPRAY.

The lime and sulphur is applied during the dormant season, usually during February or March, and is applied primarily for the San Jose scale, and, as the growers express it, to "clean up the trees." As stated above, comparatively few growers were using this spray when the records here presented were obtained. The average solution used is 1 to 10; that is, 20 gallons of lime-sulphur and 200 gallons of water.

## APHIS SPRAYS.

Another spray sometimes applied separately, but usually in conjunction with one of the lead arsenate sprays, is the aphis spray. In Mesa County on the farms studied there was no record of the use of this spray on bearing apples. In Delta County 18 men used the aphis spray. Of these, 15 applied it in combination with a lead arsenate spray, while 3 made separate sprays. In Montrose County 4 men used the aphis spray as a separate spray. In either case the usual mixture was 1½ pints of tobacco extract to a 200-gallon tank. In Montrose 203.8 gallons per acre were applied as compared to 418 for the 3 separate aphis sprays of Delta County and 558 for the 15 combination sprays.

Table XXI summarizes all spraying costs, there being a total of $30.41 for Mesa, $16.68 for Delta, and $12.36 for Montrose. The high spraying cost in Mesa has already been explained. These costs are all figured on the same man-hour and horse-hour rate basis used in figuring other orchard operations. The few who hired their spraying done were charged at the regular rate. The upkeep and depreciation of the spray rig is an important item which will be taken up under discussion of equipment and machinery depreciation.

TABLE XXI.—*Summary of costs for all sprays (125 ranches, western Colorado).*

| Item. | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Man-hours | 40.83 | 24.71 | 18.54 | 30.29 |
| Horse-hours | 29.2 | 18.21 | 12.77 | 21.87 |
| Cost per acre: | | | | |
| Labor | $14.59 | $8.91 | $6.55 | $10.85 |
| Material | 15.82 | 7.77 | 5.81 | 10.68 |
| Total | 30.41 | 16.68 | 12.36 | 21.53 |
| Cost per box: | | | | |
| Labor | .053 | .030 | .024 | .0382 |
| Material | .058 | .026 | .021 | .0376 |
| Total | .111 | .056 | .045 | .0758 |

## SCRAPING TREES.

An operation of important bearing upon the health of the tree is the scraping of the loose bark from the trunk and lower limbs of the tree. This is done usually during the winter or early spring to remove codling-moth larvæ or other insects which may be underneath the loose bark. A sharp hoe is generally used for the purpose. This practice is followed principally in the Grand Valley, where 30 growers of the 49, or 61.2 per cent, scrape their trees, some every year and others every 2 years. In Delta County only 4 practice scraping, and in Montrose none. On the farms studied the average number of trees that a man will scrape in 10 hours in the Grand Valley is 45; in Delta, according to the 4 records taken, 53. The time chargeable per acre, 3.45 hours in Mesa and 0.86 hour in Delta, has been counted under miscellaneous labor.

## MISCELLANEOUS LABOR.

All major orchard operations prior to harvesting time have been discussed, but their remain many minor items of labor which in the aggregate have considerable weight. These items, in order of importance are cleaning laterals and waste ditches (including mowing weeds along the ditches) (see fig. 9); propping; summer pruning or water sprouting; cleaning up the packing shed; hoeing weeds; mowing weeds or mulch crop to leave on the ground as a mulch; sowing mulch crops, and other occasional items. These odd costs were combined and the time distributed over the total number of records for each county. (See Table XXII.)

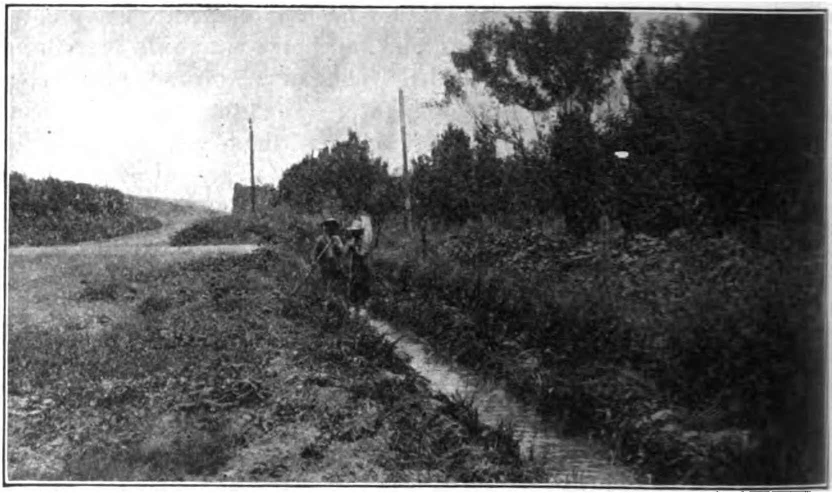


FIG. 9.—Cleaning a waste ditch in the Grand Valley district. This operation is necessary at least once a year and is one of the principal items of miscellaneous labor.

TABLE XXII.—*Miscellaneous labor (125 ranches, western Colorado).*

| Item. | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Man-hours, per acre | 12.35 | 9.58 | 11.5 | [illegible] |
| Horse-hours, per acre | .71 | 3.33 | 7.8 | [illegible] |
| Cost per acre | $3.20 | $2.89 | $4.05 | [illegible] |
| Cost per box | $0.012 | $0.010 | $0.015 | [illegible] |

## ORCHARD HEATING.

Orchard heating or smudging, as it is generally termed by growers in this region, has for several years been very much out of favor in western Colorado. There are now few men left who have the equipment to smudge and still fewer who believe in it. It is still practiced in the Palisade peach district. In the spring of 1915, when severe frosts occurred in early May, only a very few apple growers in the entire Grand Valley set out their smudge pots and saved their crops. There is no doubt that orchard heating paid that year. This was due largely to weather conditions, the night being so still that the smoke hung in thick clouds over the orchards. Such results, however, are exceptional. In the early years of the fruit industry orchard heating was a universal practice, but owing to the great expense of equipment and operation, and to frequent failure to save the crop owing to adverse weather conditions, the practice has been almost wholly discontinued. (See fig. 10.) Over 90 per cent of Mesa growers interviewed, while admitting that smudging sometimes saves the crop, maintain that as an insurance it is too expensive. There are a few men, however, who have followed the practice regularly and never lost faith in it. Some of these men are among the most successful men in the valley, but their numbers are so few and their costs and methods so various that no accurate average costs for smudging could be obtained. The apple growers on the farms studied in the lower sections of Delta County formerly practiced orchard heating, as did all those of Montrose, where many still put out their smudge pots every year.

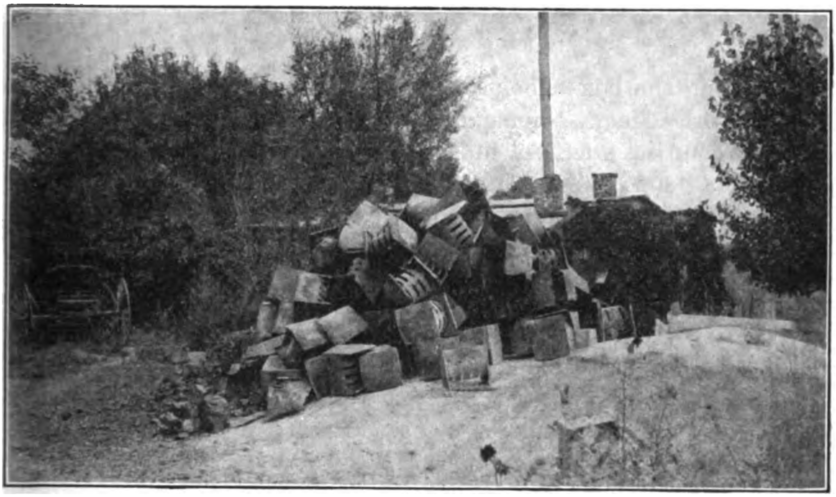


FIG. 10.—Discarded smudge pots on a ranch near Grand Junction. Smudging is now practiced by very few growers.

In the discussion of cost production no figures for orchard heating are taken into account, since not enough estimates could be obtained to constitute reliable data.

## HARVESTING OPERATIONS.

Under harvesting operations are included all those items pertaining to the harvesting of the crop from the time the apples are picked until they are delivered at the station or warehouse. These operations include hauling the box shooks, making the boxes, hauling the empty boxes to the orchard and the full ones to the packing shed, picking, grading, sorting, packing, nailing, and stamping, waiting, and all other packing-house labor, and, lastly, hauling the boxes to the loading station. These operations will be discussed under three general headings, viz, hauling, picking, and packing-house time and costs.

### HAULING.

#### HAULING BOX SHOOKS.

In hauling the box shooks all the growers on the farms studied hauled with a 1-man, 2-horse crew. The average distance hauled for the three counties was 3.11 miles, with a cost of $0.0047 per box, the average load 402 boxes. Table XXIII shows the relative cost for the farms studied in the three counties.

TABLE XXIII.—*Hauling shooks (1–2 crew).*

| County and number of records. | Man-hours per acre. | Horse-hours per acre. | Boxes per load. | Number miles. | Boxes per hour per mile. | Cost per box per mile. | Cost per acre. | Cost per box average distance hauled. |
|---|---|---|---|---|---|---|---|---|
| Mesa, 49 | 1.87 | 3.73 | 428 | 3.03 | 446.8 | $0.00123 | $1.03 | $0.00373 |
| Delta, 61 | 2.77 | 5.55 | 383 | 3.13 | 330.5 | .00166 | 1.53 | .00519 |
| Montrose, 15 | 2.94 | 5.87 | 400 | 3.3 | 305.4 | .00180 | 1.62 | .00594 |
| All counties, 125 | 2.44 | 4.87 | 402.68 | 3.11 | 373.08 | .00151 | 1.34 | .00471 |

#### HAULING FULL BOXES TO CAR.

As in hauling shooks, the ordinary crew used in hauling to the station is the 1-man, 2-horse crew. The average for the three counties is 73.5 boxes per load; distance, 2.45 miles; cost of 1 cent per box per mile, or $0.0249 per box for the average distance hauled. As will be seen from Table XXIV, the cost per box per mile varies but little.

TABLE XXIV.—*Hauling full boxes to car (1–2 crew).*

| County and number of records. | Man-hours per acre. | Horse-hours per acre. | Boxes per load. | Number miles. | Boxes per hour per mile. | Cost per box per mile. | Cost per acre. | Cost per box average distance hauled. |
|---|---|---|---|---|---|---|---|---|
| Mesa, 49 | 9.87 | 19.74 | 76 | 2.1 | 58.53 | $0.00940 | $5.43 | $0.01974 |
| Delta, 61 | 15.10 | 30.20 | 71 | 2.53 | 49.20 | .01117 | 8.31 | .02826 |
| Montrose, 15 | 14.04 | 28.08 | 76 | 3.3 | 64 | .00860 | 7.72 | .02838 |
| All counties, 125 | 12.92 | 25.85 | 73 | 2.45 | 54.63 | .01017 | 7.11 | .02492 |

### HAULING TO ORCHARD AND BACK TO PACKING SHED.

In hauling to and from the orchard it is the usual practice to haul the empty boxes out and distribute them as needed and haul full ones in on the same truck or sled. In nearly 80 per cent of the records a truck is used for this purpose. The 1–2 crew is the most common. For the smaller orchards the hauling is often done by the owner, who may also nail up the boxes or do other work about the packing house. The average load of full boxes drawn is 38 with the 1–2 crew and 20 with the 1–1 crew. In hauling out the empties the size of the load is about double the number of full boxes hauled in. Tables XXV and XXVI cover both hauling out and in. The costs per box are for packed boxes—not loose boxes as they are hauled from the orchard. The estimates in most cases were that 3 loose boxes would make 2 packed boxes and the costs are figured in that basis. Table XXVII serves to show how the counties compare in practice and time and cost per box, regardless of the method used.

TABLE XXV.—*Hauling to and from packing shed (1–2 crew).*

| County and number of records. | Yield per acre, packed boxes. | Yield per acre, loose boxes. | Man-hours per acre. | Horse-hours per acre. | Boxes per load. | Boxes in 10 hours. | Cost per acre. | Cost per box. |
|---|---|---|---|---|---|---|---|---|
| Mesa, 41 | 275 | 413 | 6.36 | 12.73 | 33 | 649 | $3.50 | $0.0127 |
| Delta, 58 | 294 | 441 | 9.82 | 19.64 | 40 | 449 | 5.40 | .0184 |
| Montrose, 15 | 272 | 408 | 10.12 | 20.24 | 42 | 403 | 5.57 | .0205 |
| All counties, 114 | 284 | 426 | 8.62 | 17.23 | 38 | 515 | 4.74 | .01662 |

TABLE XXVI.—*Hauling to and from packing shed (1–1 crew).*

| County and number of records. | Yield per acre, packed boxes. | Yield per acre, loose boxes. | Man-hours per acre. | Horse-hours per acre. | Boxes per load. | Boxes in 10 hours. | Cost per acre. | Cost per box. |
|---|---|---|---|---|---|---|---|---|
| Mesa, 8 | 275 | 413 | 8.43 | 8.43 | 20 | 490 | $3.37 | $0.01226 |
| Delta, 3 | 294 | 441 | 16.52 | 16.52 | 21 | 267 | 6.60 | .02244 |
| Montrose, 0 | 272 | 408 | ....... | ....... | ....... | ....... | ....... | ....... |
| All counties, 11 | 284 | 426 | 10.64 | 10.64 | 20 | 429 | 4.25 | .01504 |

The average distance hauled is less than in hauling shooks, for in hauling the full boxes they are hauled usually to the nearest railroad siding, while shooks are more often hauled from the main railroad station. Some growers haul part of their shooks back with them after they have taken a load of full boxes to the car, but the average time and costs are figured on the practice of the great majority of growers.

A few growers, particularly in Paonia, haul the loose boxes to the association warehouse, where they are packed at a fixed cost per box. However, none of the growers considered in these records follow this practice.

TABLE XXVII.—*Hauling to and from packing shed (125 records, western Colorado).*

| County. | Man-hours per acre. | Horse-hours per acre. | Cost per acre. | Cost per box. |
|---|---|---|---|---|
| Mesa, 49 | 6.70 | 12.02 | $3.48 | $0.0127 |
| Delta, 61 | 10.16 | 19.48 | 5.46 | .0185 |
| Montrose, 15 | 10.12 | 20.24 | 5.57 | .0205 |
| All counties, 125 | 8.79 | 16.65 | 4.70 | .0165 |

## PICKING.

Picking is one of the more expensive operations connected with the apple-growing industry. The season of picking rarely begins on standard varieties before September 1 and lasts not later than November 10. Of the standard varieties, such varieties as Jonathan and Grimes are among the first picked and Ben Davis and Gano are among the last. Generally speaking, the apples are picked approximately in order of their keeping quality.

Picking sacks opening from the bottom are generally used, the apples being transferred from the sack to the loose boxes in which they are hauled to the packing shed. Step ladders of various lengths are used. Many of the apples are reached from the ground; indeed only in the older orchards is it necessary to climb about the trees.

The picking is done almost exclusively with day labor, in which case it costs over 6 cents per packed box to pick the fruit. Pickers are sometimes hired by the box at 5 cents per box, but in the opinion of the average grower this practice does not pay, since any advantage gained is more than offset by loss entailed by careless picking. Table XXVIII shows picking costs by counties. The cost per box varies from $0.061 in Mesa to $0.072 in Montrose.

## MAKING BOXES.

The grower usually makes boxes during spare time, averaging 200 to 300 per day. When made by hired help working by the piece, the usual rate is 1 cent per box.

TABLE XXVIII.—*Picking costs in the different counties (125 ranches, western Colorado).*

| County. | Loose boxes in 10 hours. | Packed boxes in 10 hours. | Hours per acre. | Cost per per acre. | Boxes per acre. | Cost per box. |
|---|---|---|---|---|---|---|
| Mesa, 49 | 61.43 | 40.95 | 67.15 | $16.79 | 275 | $0.06140 |
| Delta, 61 | 56.28 | 37.52 | 78.35 | 19.50 | 294 | .06632 |
| Montrose, 15 | 52.33 | 34.88 | 78.27 | 19.57 | 272 | .07194 |
| All counties, 125 | 57.82 | 38.55 | 73.95 | 18.49 | 284 | .06510 |

### PACKING COSTS.

The largest item of labor connected with the harvesting of the apple crop is the packing-house cost, which includes the cost of sorting, packing, nailing, waiting, and all other packing-house labor, including the wages of a packing boss where one is used.

As will be seen from Table XXIX, there is a very wide variation in methods used. In Mesa County sizers are in common use. In most instances these are merely hand sizers, and one man sizes the apples and nails for the packers, though in some cases the labor is distributed differently, according to the size of the packing crew. In large crews it takes one man's time to wait on the packers and one man's time to nail.

TABLE XXIX.—*Packing-house practices.*

| County. | Pack. | | Sort and pack. | | Nail and wait. | | Grade and nail. | | Grade. | | Hand sort. | | Nail. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of records. | Boxes in 10 hours. | Number of records. | Boxes in 10 hours. | Number of records. | Boxes in 10 hours. | Number of records. | Boxes in 10 hours. | Number of records. | Boxes in 10 hours. | Number of records. | Boxes in 10 hours. | Number of records. | Boxes in 10 hours. |
| Mesa | 38 | 58 | 11 | 51 | 16 | 179 | 31 | 174 | 3 | 212 | 4 | 100 | 2 | 300 |
| Delta | 4 | 57 | 57 | 39 | 18 | 173 | 1 | 180 | 1 | 250 | 2 | 153 | 42 | 370 |
| Montrose | 2 | 47 | 13 | 41 | 1 | 100 | 0 | 0 | 1 | 177 | 1 | 125 | 14 | 278 |
| Counties | 44 | 57 | 81 | 41 | 35 | 174 | 32 | 174 | 5 | 212 | 7 | 79 | 58 | 345 |

In the figures for hand sorting, those for the separate counties are given in loose boxes, while for the entire region they are given in packed boxes. In figuring the cost per box, as shown in Table XXX, an average cost is arrived at for each operation, using the percentage of the 125 growers who practiced each operation, the average number of boxes which constitutes a day's work, and a labor rate of $2.50 per day (the labor rate used in calculating all packing-house operations). In actual practice, packing is largely piecework, paid for at the rate of from 4 to 6 cents per box, depending on the pack, the size of fruit, and the scarcity or abundance of help. In order to make the figures comparable, for many of the small growers do their own packing with the aid of their wives and children, the regular day rate for other packing-house labor is used, the result being practically the same as when the rate for piecework is used. The miscellaneous column includes all waiting not connected with nailing or other regular operations, trucking, overseeing, and any incidental labor about the packing house. In the farms studied the packing-house labor charge is found to be $0.068 per box in Mesa, $0.073 per box in Delta, and $0.079 per box in Montrose, or $0.072 per box as an average for the region.

**Table XXX.**—*Packing-house charge.*

| Operation. | Mesa (average yield, 275). | | | Delta (average yield, 294). | | | Montrose (average yield, 272). | | |
|---|---|---|---|---|---|---|---|---|---|
| | Per cent of records. | Cost per box.[1] | | Per cent of records. | Cost per box. | | Per cent of records. | Cost per box. | |
| | | Actual. | Regional. | | Actual. | Regional. | | Actual. | Regional. |
| Pack | 77.5 | $0.0440 | $0.0341 | 6.6 | $0.0440 | $0.0029 | 13.3 | $0.0440 | [illegible] |
| Sort and pack | 22.4 | .0610 | .0137 | 93.4 | .0610 | .0570 | 86.7 | .0610 | [illegible] |
| Nail and wait | 32.6 | .0144 | .0047 | 29.5 | .0144 | .0042 | 6.7 | .0144 | [illegible] |
| Nail | 4.1 | .0072 | .0003 | 68.9 | .0072 | .0050 | 93.3 | .0072 | [illegible] |
| Grade and nail | 63.3 | .0144 | .0091 | 1.6 | .0144 | .0002 | ........ | ........ | ........ |
| Grade | 6.1 | .0118 | .0007 | 1.6 | .0118 | .0002 | 6.7 | .0118 | [illegible] |
| Sort | 8.2 | .0316 | .0026 | 3.3 | .0316 | .0010 | 6.7 | .0316 | [illegible] |
| Wait and miscellaneous | 100 | .0030 | .0030 | 100 | .0029 | .0029 | 100 | .0096 | [illegible] |
| Cost per box | ........ | ........ | .068 | ........ | ........ | .073 | ........ | ........ | [illegible] |
| Cost per acre | ........ | ........ | $18.76 | ........ | ........ | $21.59 | ........ | ........ | [illegible] |
| Hours per acre | ........ | ........ | 75.04 | ........ | ........ | 86.37 | ........ | ........ | [illegible] |

[1] "Actual" cost is the cost for growers reporting. "Regional" cost is the actual cost distributed over all records.

The totals of all labor costs are summarized in Table XXXI. The cost per box varies from $0.37 in Delta to $0.42 in Mesa, the average being $0.394. The labor cost per acre on all records is $111.88. There is considerable variation in cost on such items as spraying and thinning, etc., owing to the difference in the intensiveness of the farming carried on in the three counties.

**Table XXXI.**—*Summary of all labor costs (125 ranches, western Colorado).*

| Item. | Mesa (49 records, 275 yield. | | | | Delta (61 records, 294 yield). | | | |
|---|---|---|---|---|---|---|---|---|
| | Man-hours. | Horse-hours. | Cost per acre. | Cost per box. | Man-hours. | Horse-hours. | Cost per acre. | Cost per box. |
| Manure | 3.71 | 7.42 | $2.04 | $0.007 | 5.03 | 9.10 | $2.62 | [illegible] |
| Prune | 62.61 | ........ | 21.91 | .080 | 47.73 | ........ | 16.71 | [illegible] |
| Haul brush | 9.75 | 12.84 | 4.36 | .016 | 8.46 | 9.90 | 3.60 | [illegible] |
| Thin | 24.36 | ........ | 6.09 | .022 | 15.42 | ........ | 3.86 | [illegible] |
| Cultivate | 18.55 | 35.63 | 9.98 | .036 | 14.08 | 28.14 | 7.74 | [illegible] |
| Irrigate | 11.59 | ........ | 2.90 | .011 | 15.66 | ........ | 3.91 | [illegible] |
| Spray | 40.83 | 29.2 | 14.59 | .053 | 24.71 | 18.21 | 8.91 | [illegible] |
| Codling-moth bands | 10.78 | ........ | 2.70 | .010 | 1.31 | ........ | .33 | [illegible] |
| Miscellaneous | 12.35 | .71 | 3.20 | .012 | 9.58 | 3.33 | 2.89 | [illegible] |
| Haul shooks | 1.87 | 3.73 | 1.03 | .004 | 2.77 | 5.55 | 1.53 | [illegible] |
| Haul to and from orchard | 6.70 | 12.02 | 3.48 | .013 | 10.16 | 19.48 | 5.46 | [illegible] |
| Haul to car | 9.87 | 19.74 | 5.43 | .020 | 15.10 | 30.20 | 8.31 | [illegible] |
| Pick | 67.15 | ........ | 16.79 | .061 | 78.35 | ........ | 19.59 | [illegible] |
| Pack, nail, grade | 75.04 | ........ | 18.76 | .068 | 86.38 | ........ | 21.59 | [illegible] |
| Make boxes | 11.00 | ........ | 2.75 | .010 | 11.76 | ........ | 2.94 | [illegible] |
| Total | 366.16 | 121.29 | $116.01 | $0.423 | 346.50 | 123.91 | $109.99 | [illegible] |

TABLE XXXI.—*Summary of all labor costs (125 ranches, western Colorado)*—Contd.

| Item. | Montrose (15 records, 272 yield). | | | | All records (125, 284 yield). | | | |
|---|---|---|---|---|---|---|---|---|
| | Man-hours. | Horse-hours. | Cost per acre. | Cost per box. | Man-hours. | Horse-hours. | Cost per acre. | Cost per box. |
| Manure | 7.77 | 15.55 | $4.28 | $0.016 | 4.84 | 9.21 | $2.59 | $0.009 |
| Prune | 48.59 | ........ | 17.01 | .063 | 53.66 | ........ | 18.78 | .066 |
| Haul brush | 6.43 | 7.78 | 2.77 | .010 | 8.72 | 10.64 | 3.78 | .013 |
| Thin | 5.35 | ........ | 1.34 | .005 | 17.71 | ........ | 4.43 | .016 |
| Cultivate | 15.25 | 30.50 | 8.39 | .031 | 15.97 | 31.36 | 8.70 | .031 |
| Irrigate | 12.99 | ........ | 3.25 | .012 | 13.74 | ........ | 3.44 | .012 |
| Spray | 18.54 | 12.77 | 6.55 | .024 | 30.29 | 21.87 | 10.85 | .038 |
| Coddling-moth bands | ........ | ........ | ........ | ........ | 4.87 | ........ | 1.22 | .004 |
| Miscellaneous | 11.50 | 7.80 | 4.05 | .015 | 10.90 | 2.84 | 3.14 | .011 |
| Haul shooks | 2.94 | 5.87 | 1.62 | .006 | 2.44 | 4.87 | 1.34 | .005 |
| Haul to and from orchard | 10.12 | 20.24 | 5.57 | .021 | 8.79 | 16.65 | 4.70 | .017 |
| Haul to car | 14.04 | 28.08 | 7.72 | .028 | 12.92 | 25.85 | 7.11 | .025 |
| Pick | 78.27 | ........ | 19.57 | .072 | 73.95 | ........ | 18.49 | .065 |
| Pack, nail, grade | 85.84 | ........ | 21.46 | .079 | 81.87 | ........ | 20.47 | .072 |
| Make boxes | 10.85 | ........ | 2.72 | .010 | 11.36 | ........ | 2.84 | .010 |
| Total | 328.48 | 128.59 | $106.30 | $0.392 | 352.08 | 123.29 | $111.88 | $0.394 |

It should be borne in mind that this table is for labor only, including no material of any kind, and that it represents but about 50 per cent of the cost of delivering a box of apples f. o. b. at the shipping station.

## YIELDS.

In determining average yields, figures were obtained for five years, where possible, and an average taken by age of trees, thus scattering light yields occasioned by frost. This method gives a fairer figure than could be obtained by taking the average by years, since in that case the light yields would be bunched. (See Table XXXII.)

Averages were taken from the ages of 13 to 18 years, inclusive. On the farms studied it was found that in Mesa County the average yield for full-bearing trees 13 to 18 years old was 275 packed boxes or 3.9 boxes per tree. On those in Delta County there was an average yield on the same age trees of 294 boxes per acre or 3.8 boxes per tree, and in Montrose County there was an average of 272 boxes, or 3.8 boxes per tree.

TABLE XXXII.—*Average yield per acre and per tree (125 ranches, western Colorado).*

| County. | Yield per acre. | Yield per tree. | Number of estimates of different ages. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 13 years. | 14 years. | 15 years. | 16 years. | 17 years. | 18 years. | 13 to 18 years inclusive. |
| Mesa | 275 | 3.9 | 22 | 23 | 26 | 20 | 21 | 14 | 126 |
| Delta | 294 | 3.8 | 40 | 33 | 31 | 31 | 27 | 13 | 175 |
| Montrose | 272 | 3.8 | 11 | 10 | 9 | 6 | 6 | 2 | 44 |
| All counties | 284 | 3.8 | 73 | 66 | 66 | 57 | 54 | 29 | 345 |

In arriving at these averages the same weight is given each age, regardless of the number of estimates, thus avoiding weighted averages. In getting a yield for the three counties, however, an average is figured on the basis of the 125 records as though there were no division in counties, thus giving each record its proper weight in the grand average of all records.

On the farms studied it was found that the average yield for all apple orchards between the ages of 13 and 18 years was 284 boxes per acre, or 3.8 boxes per tree. The uniformity of the yield in the three different counties shows that these figures present a fairly accurate average. The yield is only for packed boxes of marketable fruit. To express the yield in terms of loose boxes, one-half must be added to this average. Packing-house managers and growers agree that on an average three loose boxes pack out two packed boxes.

If the average yield for each individual record is taken regardless of age of trees, the average of all orchards is 278 boxes per acre.

In order to determine the influence of the size of orchard on yield, 104 individual records of fairly uniform ages were used. Of these, 35 were over 10 acres in size., 47 were between 6 and 10 acres, inclusive and 22 were 5 acres and under.

TABLE XXXIII.—*Relation of size of orchard to yield.*

| Size orchard. | Number of orchards. | Yield per acre (boxes). |
|---|---|---|
| Over 10 acres | 35 | 230 |
| 6 to 10 acres, inclusive | 47 | 285 |
| 1 to 5 acres, inclusive | 22 | 306 |

It is apparent from Table XXXIII that size of orchard has a direct bearing on the yield per acre. The number of trees per acre remained practically constant. The large yields per acre on the small orchards may be accounted for, in part, by the better care which they receive, since a grower naturally can attend to more details with a five-acre orchard than with one of twenty.

The different systems of orchard management as regards the use of mulch crops and clean cultivation made no appreciable difference in the yields. However, a comparison by this method would not be fair in this connection, since mulch crops have not been in use long enough to affect the average yield when these records were taken. It may be said that the use of mulch crops apparently has not decreased the yield, while continued intensive clean cultivation with no addition of humus has decreased it. Orchards regularly manured showed a yield much above the average. Systematic thinning also increases the yield of marketable fruit.

The drop or cull apples are not counted in the yields. Generally speaking, these are as yet practically waste in Colorado. A few are hauled to vinegar factories, some are made into cider, some fed to stock, but the great bulk of cull fruit is not marketed in any way and thus can not be credited to the orchard. By systematic thinning, spraying, etc., this unmarketable fruit is reduced to a minimum; indeed is almost entirely eliminated by a few of the more careful growers.

## MARKETING.

The apples are marketed usually in three grades, namely, "Extra fancy," "Fancy," and "Choice" or "C" grade. In Montrose County, however, there is a tendency to make a jumble pack.

At the time of this study the fruit was marketed largely through selling organizations, cooperative and otherwise. The growers contract with these organizations and agree to allow them to handle their fruit, either at a fixed cost per box or on commission. The usual custom with cooperative selling organizations has been to handle the fruit at a cost of 10 cents per box. Growers often market their own fruit, but to do this they have to follow it up, and serious difficulties are often encountered.

## MATERIALS AND FIXED COSTS.

The expenses other than labor may be grouped into "fixed costs" and material costs. (See Table XXXIV.) The fixed costs include taxes, water rent, insurance, interest, and depreciation, while the material costs include boxes, nails, paper, labels, lime-sulphur, lead arsenate, and all other spray materials. There is also the cost or value of manure charged to the orchard, which is a material cost. Included among cash costs is the spray rig hire. This refers only to the rig itself, as all man and horse labor is charged elsewhere. It is necessary for this cost to appear, since 24.5 per cent of the men in Mesa, 16.4 per cent in Delta, and 6.6 per cent in Montrose hire spraying done, and the cost of the spraying equipment is not charged in the depreciation charges which appear. Therefore, the cost of hiring these rigs at 45 cents per hour for the use of the rig alone is distributed over all the records.

TABLE XXXIV.—*Material and fixed costs (125 ranches, western Colorado).*

| Item. | Mesa (275). | | Delta (294). | | Montrose (272). | | All counties (284). | |
|---|---|---|---|---|---|---|---|---|
| | Cost per acre. | Cost per box. | Cost per acre. | Cost per box. | Cost per acre. | Cost per box. | Cost per acre. | Cost per box. |
| Box shook, at 12½ cents | $34.38 | $0.1250 | $36.75 | $0.1250 | $34.00 | $0.1250 | $35.50 | [illegible] |
| Nails | 1.10 | .0040 | 1.18 | .0040 | 1.09 | .0040 | 1.14 | [illegible] |
| Paper | 1.10 | .0040 | 2.03 | .0069 | 1.77 | .0065 | 1.63 | [illegible] |
| Labels | 1.37 | .0050 | 1.47 | .0050 | 1.36 | .0050 | 1.42 | [illegible] |
| Lime sulphur, at 23 cents per gallon | 3.80 | .0138 | .24 | .0008 | 1.20 | .0044 | 1.75 | [illegible] |
| Tobacco extract, at $1.56 per pint | ........ | ........ | 1.84 | .0063 | .63 | .0023 | .97 | [illegible] |
| Lead arsenate, at 10 cents per pound | 12.02 | .0437 | 5.68 | .0193 | 3.98 | .0146 | 7.98 | [illegible] |
| Manure, at $1.50 per ton | 3.57 | .0129 | 6.38 | .0217 | 6.35 | .0233 | 5.27 | [illegible] |
| Gasolene, at 20 cents per gallon | .91 | .0033 | .57 | .0019 | .40 | .0015 | .68 | [illegible] |
| Cash machine hire | 1.61 | .0059 | .67 | .0023 | .19 | .0007 | .98 | [illegible] |
| Taxes | 5.23 | .0190 | 3.30 | .0112 | 2.56 | .0094 | 3.97 | [illegible] |
| Water rent | 1.95 | .0070 | 1.84 | .0063 | 1.33 | .0049 | 1.82 | [illegible] |
| Insurance | .83 | .0030 | .42 | .0014 | .36 | .0013 | .57 | [illegible] |
| Interest | 60.13 | .2187 | 50.21 | .1708 | 35.14 | .1292 | 52.29 | [illegible] |
| Depreciation and upkeep of equipment | 9.01 | .0328 | 5.99 | .0204 | 7.79 | .0286 | 7.39 | [illegible] |
| Packing-house annual upkeep | 3.75 | .0136 | 5.40 | .0184 | 3.90 | .0143 | 4.57 | [illegible] |
| Total | 140.76 | .512 | 123.97 | .422 | 102.05 | .375 | 127.91 | [illegible] |

The depreciation on equipment, together with the upkeep and interest on the equipment, was arrived at by estimates of growers on the length of life of the equipment, which varies according to the tool used and whether it is housed or not. The equipment charge per acre of apple orchard is figured in the following way:

| | Per cent. |
|---|---|
| Interest | 8 |
| Depreciation | 11 |
| Taxes | 1 |
| Repairs | 5 |
| Annual charge | 25 |

In order to get a comparable figure for the equipment investment per acre of bearing apples, the following method was used:

Value of apple orchard per farm divided by land and improvement investment per farm equals percentage of value of land investment which apple orchard represents. This percentage multiplied by equipment investment per farm equals equipment investment per orchard.

Equipment investment per orchard multiplied by 25 per cent equals annual equipment charge per orchard.

Annual equipment charge per orchard divided by average size orchard equals annual equipment charge per acre.

On most of the ranches studied there is some building erected especially for apples. This may be either a packing shed or cellar for temporary storage. A few growers have expensive packing houses, but the majority are simple frame structures erected at a small cost. In many cases these sheds are a part of the barn, and may be used for other purposes, in which case only the proportionate share of the value is charged to the orchard. The investments in such buildings range from $25 to $3,000, but very few have packing houses or cellars costing $1,000 or over. It was found that the growers of Mesa have an investment of $25 per acre for buildings of this kind; those of Delta, $36 per acre, and those of Montrose, $26 per acre. The annual charge on these apple buildings is, according to estimates, 15 per cent, divided about as follows:

| | Per cent. |
|---|---|
| Interest | 8 |
| Depreciation | 3 |
| Repairs | 3 |
| Taxes | 1 |
| Total | 15 |

There is, then, an annual charge of $3.75 per acre in Mesa, $5.40 per acre in Delta, and $3.90 per acre in Montrose for buildings or cellars directly connected with handling the apples.

In figuring cash or material costs, the following factors are considered:

Box shooks, ready to be made up, at 12½ cents.

Nails, at $4 per keg (5d). Allow one keg to 1,000 boxes, or $0.004 per box.

Paper:

- Mesa County—50 pounds of sides, at 7½ cents pound per 950 boxes, or $0.004 per box.
- Delta County—64 pounds of sides, at 7 cents, and 34 pounds of ends at 7 cents, for 1,000 boxes, or $0.0069 per box.
- Montrose County—60 pounds of sides at 7 cents, and 32½ pounds of ends at 7 cents, for 1,000 boxes, or $0.0065 per box.

Labels put on by the association at one-half cent per box or by owners at one-third cent and labor of applying.

Lime sulphur (1–10 solution used) at $11.50 per barrel, or 23 cents per gallon.

Tobacco extract at $12.50 per gallon, or $1.56 per pint, used 1½ pints to 200 gallons of water.

Paste form arsenate of lead generally used; 8 pounds in Mesa, 8.02 pounds in Delta, and 10.22 pounds in Montrose to 200 gallons of water. Average cost per pound, $0.10.

Manure, 2.38 tons per acre in Mesa, 4.25 tons in Delta, and 4.23 tons in Montrose, at $1.50 per ton.

Gasoline, average 1 pint per horsepower per hour; spray rigs average 2½ horsepower; 14.6 engine-hours in Mesa, 9.11 in Delta, and 6.39 in Montrose, or 4.56 gallons in Mesa, 2.85 gallons in Delta, and 1.99 gallons in Montrose, at 20 cents per gallon.

Spray rig hire: Figures for the use of rig alone, at 45 cents per hour, using average engine-hours per acre for each county and distributing over all records.

Water tax figured from average annual rent or cost of maintenance per acre.

Taxes: Percentage total investment bearing orchard represents multiplied by taxes per farm divided by average size orchard equals tax per acre.

Insurance: Percentage total investment bearing orchard represents multiplied by insurance divided by average size orchard equals insurance per acre.

Equipment charge fully explained above.

Packing house: 15 per cent annual charge for interest, upkeep, depreciation, etc.

Interest: Value of apple orchard per acre multiplied by 8 per cent interest.

## SUMMARY OF ALL COSTS.

In Table XXXV is given a summary of all costs, including every item of expense chargeable to the orchards on all records.[1]

TABLE XXXV.—*Summary of all costs.*

| Item. | Mesa. | Delta. | Montrose. | All counties. |
|---|---|---|---|---|
| Total labor cost per acre | $116.01 | $109.99 | $106.30 | $111.88 |
| Total material and fixed cost per acre | 140.76 | 123.97 | 102.05 | 127.91 |
| Total all costs per acre | 256.77 | 233.96 | 208.35 | 239.79 |
| Total labor cost per box | .423 | .373 | .392 | .394 |
| Total material and fixed cost per box | .512 | .422 | .375 | .450 |
| Total all costs per box | .935 | .795 | .767 | .844 |

This, it should be borne in mind, is the average cost of all records figured on the acre basis and giving all an equal weight. Care was taken to include every item, and the figures obtained may be considered as fairly accurate averages for the region. The comparatively high cost in Mesa County is due primarily to the more intensive system practiced there and to the fact that the investment per acre in bearing orchard is considerably greater in Mesa than in the other counties. The cost, therefore, of producing a box of apples in the Grand Valley is greater on the average than in Delta or Montrose Counties. When all of the 125 records are considered it was found that the cost was $0.844 per box, which, for all practical purposes, may be said to be the average annual cost per box of producing apples in western Colorado.

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[1] No account is taken of smudging, which is not a regular practice, nor of credit for the mulch crop taken off as hay, which credit at the time the records were taken would about balance the cost of taking it off, which was not a practice.

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